Conservation in Cities: Linking Citizen Science and Civic Ecology Practices

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Introduction

Public participation in scientific research (PPSR) is a field concerned with ecological monitoring efforts that engage public volunteers in scientific investigations (Shirk et al., 2012). Citizen science is the term used to describe such studies that are initiated and driven by scientists, but facilitate non-professional involvement in data collection on a large-scale (Bonney, Cooper, et al., 2009). Citizen science projects have resulted in multiple scientific and educational outcomes. With respect to science, these projects have generated historical documentation of phenological changes; comprehensive bodies of data regarding the populations and distributions of different species; and records of local-level environmental changes due to air, water, and land pollution. This breadth of information has been widely applied to formal scientific studies and publications, as well as technical and government reports (Devictor et al., 2010; Lawrence, 2009; Loperfido et al., 2010). Citizen science projects have also created countless educational volunteer opportunities for people of all ages and backgrounds, which are relevant to their communities, offer hands-on experiences, and have helped increase scientific literacy (Brossard et al., 2005; Jordan et al., 2009). Further, participation in citizen science projects is hypothesized to enhance individuals' understandings and awareness of their local biodiversity and environment (Paige et al., 2010).

At a recent conference, PPSR practitioners acknowledged the benefits of such outcomes, but recognized that in moving forward they must strive to better incorporate direct environmental stewardship and conservation action as part of citizen science projects (American Museum of Natural History et al., 2011). Mueller et al. (2012) further underscore that "citizen science, as it is currently conceptualized, does not go far enough to resolve the concerns of communities and environments" (p. 1). Regarding conservation action, several initiatives are underway to more rigorously apply citizen science data to natural resource management laws, regulation, and planning (Cooper et al., 2012; Mayer, 2010; Seely, 2009). However, a need exists to incorporate PPSR in hands-on environmental stewardship projects in which professionals and volunteers are directly engaged in restoration and related practices. Civic ecology practices, which entail hands-on engagement in community-based stewardship that has both environmental and social outcomes (Krasny & Tidball, 2012), offers a means for partnering with citizen science and PPSR projects more broadly to further conservation outcomes (Tidball & Krasny, 2011).

Civic ecology practices could in turn benefit from citizen science and PPSR, as there is often a lack of formal monitoring to determine the impacts of restoration efforts (Krasny et al., 2013, in review; Silva, 2013). Thus citizen science and PPSR protocols could be applied to assess the ecological and possibly social impacts of civic ecology practices. In this report, we first present background on citizen science and civic ecology separately, before discussing how the practices of citizen science and civic ecology could be mutually beneficial.

Citizen Science

Background

The term citizen science applies to large-scale initiatives that engage volunteers in the scientific research process (Bonney, Cooper, et al., 2009; Dickinson et al., 2010; Thompson & Bonney, 2007). The countless citizen science projects being undertaken around the world today encompass many fields of study, and involve a range of different tasks such as reporting weather patterns; monitoring diverse species including insects, earthworms, fish, reptiles, amphibians, and mammals, among other organisms; engaging in discovery research of protein folding (Dickinson et al., 2010); and tracking the presence and spread of invasive plant species (Gallo & Waitt, 2011). At the forefront of citizen science initiatives, however, are those concerned with astronomy and ornithology. Not only do these fields engage the highest numbers of amateur experts, they also have attracted the participation of volunteers for the longest period of time (Dickinson et al., 2010). For example, astronomy-related citizen science projects were in existence as early as 1874, with the British-funded "Transit of Venus" project. To acquire a more precise measurement of the Earth's mean distance to the Sun, this initiative inspired both the interest and voluntary participation of the general public, particularly the renowned amateur astronomers of the time (Ratcliff, 2008). Among the many citizen science projects with an astronomy focus is the long-term American Association of Variable Star Observers. Initiated in 1911, it currently has over a thousand observers in 52 countries submitting hundreds of observations on variable stars each year (American Association of Variable Stars, 2011).

Volunteer data collection in ornithology has an even lengthier history. Professor Johannes Leche of the Finnish Turku Academy launched the first large-scale, collaborative survey of birds in the spring of 1749, by enlisting volunteers to record the arrival dates of migrant species (Greenwood, 2007). Like the field of astronomy, the ornithological realm also has very long-standing citizen science projects, such as the annual Christmas Bird Count and the Breeding Bird Survey. Overseen by the National Audubon Society, the Christmas Bird Count was initiated in 1900 by ornithologist Frank M. Chapman of the American Museum of Natural History, who wanted to protest the traditional holiday bird hunt that took place at that time (Stoner & Hackert-Stoner, 2007).

In 1962, Rachel Carson's (1962) book *Silent Spring* sparked widespread public concern about the negative impacts of the pesticide DDT on bird populations at both regional and national levels. The U.S. Geological Survey's Patuxent Wildlife Research Center responded to the outcry by developing the Breeding Bird Survey (U.S. Fish and Wildlife Service, 2010). Today, the Breeding Bird Survey is jointly coordinated by the Patuxent Wildlife Research Center and Environment Canada. These two institutions oversee the efforts of thousands of volunteers who undertake bird data collection in the spring along randomly-selected roadsides throughout North America. These data inform scientists, conservation managers, and the public about current populations and distributions of different bird species.

It was only one year earlier, in 1965, that the Cornell Lab of Ornithology (CLO) began its Nest Record Card Program, now known as NestWatch (Cornell Lab of Ornithology, 2013a). This initiative is but one of CLO's many bird-focused citizen science projects in operation today, such as eBird, and CLO itself that coined the term citizen science for these data collection efforts in the mid-1990s (Thompson & Bonney, 2007). eBird is an online database that collects and compiles bird observations submitted by any individual, anywhere around the world, at any time (Audubon & Cornell Lab of Ornithology, 2011). CLO has been a leader in developing, disseminating, and evaluating the impacts of citizen science, and has contributed significantly to the body of literature describing the challenges and benefits of involving volunteers in large-scale scientific research endeavors. Further, recognizing that the types of collaborations among scientists and lay people assume various forms in addition to the citizen science model of volunteer data collection for scientist-driven research, scholars at CLO have proposed a typology of Public Participation in Scientific Research (PPSF) partnerships (Shirk et al., 2012).

Scientific outcomes of citizen science

Thompson and Bonney (2007) assert that two key goals of citizen science projects are: "first, to gather data for studying scientific questions at continental or even global scales, and second, to increase scientific and/or conservation literacy among project participants" (p. 1). The achievement of these goals has contributed to the fields of science, education, and environmental conservation. With respect to science, studies and publications have relied heavily on the large data sets generated by citizen science projects. This is evidenced by the fact that to date more than 200 scientific papers, many of which were published in reputable scientific journals, are based on data collected through citizen science programs (Devictor et al., 2010). For example, an analysis of phenological data collected through a citizen science project in Britain showed that between 1971 and 2000, 78% of leafing, flowering, and fruiting plants advanced in the timing of their appearance (Lawrence, 2009). Citizen documentation of lilac blooming times in the United States exposed how the onset of spring has advanced one week relative to 30 years ago (Mayer, 2010). Such information is particularly significant in light of the accumulating evidence for global climate change. Also relevant to our understandings of global climate change is citizen science data concerning the observed timing of bird migrations. Hurlbert and Zhongfei (2012) determined that for each degree Celsius of spring temperature warming, bird species adjusted their spring arrival dates in North America up to 6 days earlier.

Another ornithological study used data gleaned solely from citizen science projects, including the Christmas Bird Count, the Breeding Bird Survey, and Project FeederWatch, to examine competition between House Finches and House Sparrows (Cooper et al., 2007). Citizen science data have been used in scientific research and publications of other vertebrate species, such as a volunteer sighting network used to help study the swim speed, behavior, and movement of North Atlantic Right Whales (Hain et al., 2013), as well as in studies of a diversity of topics such as global night sky luminance (Kyba et al., 2013). Finally, citizen scientists, including those in volunteer water quality monitoring groups, collect data related to environmental pollution. Cooper (2013) describes how citizens in communities affected by industrial pollution have monitored environmental toxins in their water and air, thereby “collecting data needed for developing new zoning laws and enforcement” (p. 1). Environmental pollution data collected by citizens has also been formally presented in both journal articles and technical reports (Loperfido et al., 2010).

Learning outcomes of citizen science

Citizen science projects have created countless educational opportunities that can increase the scientific literacy of those involved (Bonney, Ballard, et al., 2009; Brossard et al., 2005; Jordan et al., 2011; Trumbull et al., 2000). For example, in an empirical study of participants engaged in The Birdhouse Network, an evaluation pointed to an overall increase in the scientific understandings of cavity-nesting birds and their habitat requirements (Brossard et al., 2005). The results of this study also suggested that contributors to citizen science projects can learn simultaneously about the process of scientific inquiry, in addition to the particular species or events being investigated (Bonney et al, 2009). In another CLO citizen science initiative, The Seed Preference Test, over 700 participants wrote unsolicited letters reflecting on their experiences with the project. According to a content analysis of these letters, “nearly 80% revealed that participants had engaged in thinking processes similar to those that are part of science investigations” (Trumbull et al., 2000, p. 265). While Jordan et al.’s (2011) empirical study of a three-day citizen science program that involved collecting data on non-native invasive plants occurrence, as well as education about these species, showed insufficient participation for elevating understandings of the scientific research process, the participants did report an “increased ability to recognize invasive plants and increased awareness of effects of invasive plants on the environment” (p. 1148).

Environmental outcomes of citizen science

In addition to scientific and educational outcomes, citizen science data have made valuable contributions to conservation endeavors, by providing information about species abundance and behaviors, which in turn informs the development and implementation of management strategies. For example, the annual “State of the Birds” report, a joint effort of the U.S. Fish and Wildlife Service and the North American Bird Conservation Initiative, relies significantly on eBird data (North American Bird Conservation Initiative, 2013). Like the Breeding Bird Survey, the data synthesized in the State of the Birds reports informs professionals in the fields of conservation and natural resources management about current populations and distributions of different bird species, and helps raise concern for birds among the general public. The authors of an upcoming publication on bird migration used sightings reported by thousands of amateur bird watchers. They argue that based on such powerful, collective data, they have been able to make important determinations such as the locations of migratory stopover spots, and to make specific management recommendations (La Sorte, 2013; Cornell Lab of Ornithology, 2013b). Next we explore how, in addition to contributing to regional studies and management recommendations, citizen science may also be able to partner with civic ecology practices to impact conservation on a local level, including in cities.

Civic Ecology Practices

Civic ecology practices, which often take place in cities, are community-based stewardship efforts including community gardening, planting trees, removing invasive species, restoring native habitat, and reintroducing native species such as oysters in the NYC estuary or Western Red Cedar in Seattle city parks. These self-organized initiatives are not only ecologically beneficial, but also have noteworthy social impacts. According to Krasny and Tidball (2012) of Cornell University's Civic Ecology Lab, civic ecology practices "have positive outcomes for individuals, communities, and local ecosystems, and thus represent a change in thinking – from humans as apart from and destructive of the environment to humans as part of and stewards of the environment" (p. 267). Krasny and Tidball (2012) also explain ten overarching hypotheses regarding "idealized" civic ecology practices. The first hypothesis is that a tipping point, or a point at which a social-ecological system shifts into a new state due to a disturbance, can spark civic ecology practices. For example, after natural disasters or conflict, individuals may come together to start a local garden or re-plant trees. Some community gardens cultivate crops that are traditionally grown in other parts of the world, but allow individuals no longer living in their ancestral or home land to maintain long-standing cultural traditions. This is exemplified by the various types of Southeast Asian vegetables being grown by Hmong refugees in Sacramento, and also illustrates the second hypothesis of civic ecology practice: "encompassing social–ecological memories in civic ecology practices fosters individual and community resilience" (p. 268). Civic ecology practices also help promote both physical and psychological well-being, as embodied by the third hypothesis, in addition to fostering a sense of place, the fourth hypothesis of civic ecology practices. The fifth hypothesis refers how initially small practices can grow into larger-scale efforts involving multiple partnerships with regional, state, and national organizations and institutions, and thereby make a bigger difference.

The sixth hypothesis of civic ecology practices is that monitoring of these practices by citizens can inform future adaptations and changes. This hypothesis is exemplified by the oyster seeding efforts of students at a youth development and environmental education organization based in the Bronx, called Rocking the Boat (RTB). As civic ecology practitioners monitor the results of their practices, they can in turn adapt and change project goals based on the knowledge gained through their ongoing data collection. Civic ecology practices also facilitate cultural and scientific learning, the seventh hypothesis, as many of these practices connect individuals with the cultures and traditions of residents in a particular place. The eighth hypothesis is that civic ecology practices can support the development of healthier communities. Specifically, civic ecology practices can result in more green spaces where abandoned lots and even neighborhoods once stood. Greenery can contribute to the mental and physical well-being of individuals, as well as help decrease crime and other social problems on a community-level. By engaging in the civic ecology practices that produce green spaces or thriving community gardens, individuals can build stronger relationships with others while helping to enhance local ecosystem services. Thus, "civic ecology practices represent nested processes that interact across individual, community, and ecosystem scales" (Krasny & Tidball, 2012, p. 271), the ninth hypothesis.

The tenth and final hypothesis is that social-ecological resilience can result from civic ecology practices. Specific attributes of civic ecology practices that help foster such resilience include the aforementioned enhancement of ecosystem services, through the use of scientific and local knowledge, self-organized and/or partnership efforts, as well as social learning. Social learning is "the process by which stakeholder interactions go beyond participation to concerted action that brings about policy change, or more generally a collaborative process among multiple stakeholders aimed at addressing management issues in complex systems" (Krasny & Tidball, 2009, p. 6).

Enhancing the Conservation and Stewardship Goals of Citizen Science

A concerted integration of civic ecology practices into citizen science projects could help support the latter field's objective of enhancing overall conservation action and environmental stewardship outcomes (American Museum of Natural History, 2011). This argument is based upon two key pillars. First, a principal goal of civic ecology is to engage individuals in hands-on conservation endeavors (Krasny & Tidball, 2012), whereas citizen science projects prioritize data collection to help address a scientific research question (Mueller et al., 2012). Second, civic ecology projects strongly emphasize the need for inclusive planning and participation (Tidball & Krasny, 2010). It is argued that collaborative, hands-on experiences with environmental action can have a meaningful impact on personal stewardship values as well as more effectively address conservation issues (Busch & Dayer, 2008; Chawla & Cushing, 2007; Roth & Lee, 2004). The following section will discuss these two pillars in greater detail, before describing how citizen science practices can in turn support civic ecology practices.

Hands-on conservation endeavors

Civic ecology projects prioritize ecological restoration at the community level, with the involvement of diverse local citizens. This approach has been informally described as putting the conservation behavior first, rather than focusing primarily on acquisition of knowledge (Krasny, 2013). Citizen science projects, on the other hand, are above all concerned with facilitating individuals' engagement in scientific investigations, in order to acquire knowledge. Mueller et al. (2012) argue that "participants [in citizen science projects] primarily serve to collect data for scientists" (p. 3). Even when citizen science projects claim to make stewardship the priority, they can in reality be most concerned with data collection. For example, in Project Citizen, which purports to be dedicated to student participation in citizen science explicitly geared towards action (Green & Medina-Jerez, 2012), the dominant component of the project by far is still the research dimension.

Certain examples of citizen science initiatives do have a strong stewardship component. The Monarch Larva Monitoring Project not only oversees the collection of data on this butterfly species' habitat and populations (University of Minnesota, 2013), but supports participants in protecting unused fields for wildflower gardens (Cooper, 2013). In the case of the Australian Waterwatchers group, "monitoring has given way to restoration with streamlining projects, silt-trapping efforts, weed control projects, roadside revegetation plans, riparian zone fencing, tighter controls on drains and a ban on new septic tank systems" (Carr, 2002, p. 29). Such examples do not appear to be the norm, however.

It should also be noted that a large majority of citizen science projects focus on scientific research questions that are ultimately concerned with a future conservation purpose such as preserving biodiversity (Dickinson et al., 2010). However, individual participants could, in *addition* to collecting data, be engaged in greater hands-on stewardship action at the local level, in keeping with the practices of the Monarch Larva Monitoring Project (University of Minnesota, 2013) and Waterwatchers (Carr, 2002). In civic ecology projects, the undertaking of a specific environmental initiative with tangible impacts is always the cornerstone of practice, which is why citizen science might consider how elements of the civic ecology model could help address citizen science conservation goals. Finally, though not the focus of this article, civic ecology practitioners could in turn greatly benefit from the formalized monitoring of citizen science to more rigorously assess the effectiveness of their stewardship actions. In fact, outcomes monitoring is largely absent from civic ecology practices, although efforts are being made to form partnerships with university and other scientists to enhance the capacity to measure impacts (Krasny et al., 2013, in review; Silva, 2013).

Inclusive planning and participation

Another aspect of civic ecology practices is that they directly involve participation of (and in most cases are initiated by) community members, and are thus may be meaningful from a personal stewardship perspective. While some suggest that "volunteers [in citizen science projects] may also develop a greater sense of stewardship over the populations or sites they are responsible for surveying or monitoring" (McCaffrey, 2005, p. 71), other research indicates that simply exposing people to wildlife and the environment does not necessarily influence their attitudes and behaviors towards the natural world (Brossard et al., 2005; Busch & Dayer, 2008). A case in point is the study of the participants engaged in The Birdhouse Network, described above. The results did not indicate any changes in attitudes towards the environment, although scientific understandings of cavity-nesting birds and their habitat requirements did increase. The authors argue that their findings underscore a need for citizen science projects to more explicitly highlight and address the relevant environmental issues (Brossard et al., 2005). In another study of a bird-banding education program, participants similarly showed heightened scientific knowledge of birds, but no significant changes in attitudes or behaviors. While this is not an example of a citizen science project, the authors' explanation of their results is pertinent to the argument at hand: stronger personal stewardship outcomes may be more likely to result from educational experiences that go beyond the transmission of knowledge and information to the development and reinforcement of environmental action skills (Busch & Dayer, 2008). Although evidence of outcomes of civic ecology practices is just starting to emerge (e.g., Kudryavtsev et al., 2012), based on the knowledge we have of such practices and the literature about citizen science and hands-on stewardship, we argue that linking citizen science and civic ecology practices warrants greater consideration, application, and evaluation.

Evidence for this suggestion can be found in Roth and Lee's (2004) study of youth participants in a scientific inquiry project focused on their local environment. The target issue was water contamination, and the students were afforded a great deal of autonomy over their own work and the opportunity to engage in direct action. The students' investment in the problem showed a measurable increase, which in turn inspired changes in their environmental choices and behaviors. Chawla and Cushing (2007) reviewed the outcomes of various studies examining the changes in environmental concern and action amongst youth participants in school-based, after-school, or non-formal EE programs, and also determined that the programs with the greatest effect were those that exhibited “an extended duration of time, opportunities to learn and practice action skills, and success in achieving some valued goals” (p. 441). Chawla and Cushing also argue that emphasizing collective action, rather than individual behaviors, is a far more effective approach to addressing environmental issues. Thus facilitating participation in such collaborative projects is a potentially powerful educational strategy for promoting stewardship and conservation initiatives on a wider scale. Civic ecology projects undoubtedly exemplify collaboration aimed at addressing local environmental issues. Finally, Mueller et al. (2012) assert that “teaching about rather than engaging in is a widely known problem in schools, and citizen science offers very little that the textbooks or teacher lectures do not already disguise” (p. 3). We would argue that many citizen science practices do expose individuals to important educational experiences that allow them to gain both a heightened awareness of their surroundings, a feat that should not be dismissed. However, the concerted adoption of civic ecology practices could help increase both individuals’ knowledge regarding the threats to local biodiversity, as well as their hands-on engagement in collective action addressing these threats.

Linking civic ecology and citizen science practices

Civic ecology projects could in turn be supported by the implementation of citizen science practices, creating a positive feedback loop. Given the paucity of monitoring in civic ecology practices, citizen science protocols could help practitioners assess how planting trees or nurturing community gardens have influenced the presence of flora and fauna, the quality of local air and water, as well as social or cultural outcomes such as forming connections among community members (Krasny et al., in review). Tidball and Krasny (2010) argue that “incorporating data collection efforts, such as those of citizen science programs, with civic ecology education, may help to provide the information needed to allow... [resource management] feedbacks to occur” (p. 11). Furthermore, as stated above, social-ecological resilience is among the goals of civic ecology practices, and monitoring is an important contributor to the social learning process essential to such resilience (Tidball & Krasny, 2010). As part of a Land Grant fellowship through Cornell University, the first author worked with the community organization Rocking the Boat to design and implement a project linking civic ecology and citizen science practices in the Bronx, NYC. Although the project did not encompass formal evaluation, we offer it as an example of how one could begin to link civic ecology and citizen science.

Linking Civic Ecology and Citizen Science Practices in Action!

Rocking the Boat (RTB) works with "young people challenged by severe economic, educational, and social conditions to develop the self-confidence to set ambitious goals and gain the skills necessary to achieve them" (Rocking the Boat, 2013, p. 1). The organization accomplishes its goals through on-water programs in boats that have been (for the most part) built by staff and students on-site. In collaboration with Cornell University's Civic Ecology Lab and the Cornell Lab of Ornithology, Chrissy Word, RTB's Director of Public Programs, developed and executed an ongoing initiative called the Tree Swallow Breeding Project. Through this project, youth participants in RTB's programs are building Tree Swallow nest boxes in their boatbuilding shop; installing these boxes in nearby parks and restoration areas; monitoring the activity of the Tree Swallows that ultimately use the boxes, as well as other species of birds in the vicinity; and contributing their observational data to eBird. Thanks to the support of the Land Grant Fellowship, the first author has supported the project in co-designing the pilot program, and through facilitating classes to engage the students in relevant learning about the significance of birds to our planet, the natural history of Tree Swallows, and the protocols for building nest boxes and eBird data collection. The civic ecology component of the project, which is the creation of Tree Swallow nesting sites, involves participants in hands-on, local habitat restoration. These efforts are in turn supported by the citizen science dimension, as the data collected through the monitoring activities can provide insight into whether or not the stewardship efforts are indeed having a positive impact on birds.

RTB students finishing a nest box. Photo credit: Lilly Briggs.

RTB students installing a nest box. Photo credit: Lilly Briggs.

Tree Swallow pair using a nest box. Photo credit: Joseph Morales.

Conclusion

The fields of citizen science and civic ecology both make meaningful and needed contributions to conservation. Citizen science practices provide data that can positively influence natural resource management practices, while civic ecology practices make contributions through hands-on stewardship efforts that engage local citizens in planting trees, restoring native habitats, and creating community gardens, among other community-based initiatives. In order to support the respective interests of citizen science practitioners in having a greater impact on local conservation, and civic ecology practitioners in better documenting their stewardship outcomes, we call for a more concerted pursuit of opportunities for collaboration between the two fields.

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