CITIZEN SCIENCE

A TOOL FOR CONSERVATION

A WHITE PAPER PUBLISHED BY SCIENCE CONNECTED

Open-access Peer-reviewed

Copyright Notice

Contents

Contents

Citizen science efforts help track endangered species, like most species of sea turtle.

Introduction

Science, particularly the science of conservation, is often a collaborative process. Whether within a single discipline or across numerous fields, people work together to achieve goals. When it comes to environmental science, those goals may be as narrow as identifying what chemical compounds are released into a series of streams due to toxic water runoff, or as broad as establishing protections for endangered species across the globe.

Citizen science is a term that applies to a collaborative scientific process in which non-scientists, or citizen scientists, participate. Garbarino and Mason (2016) define a *scientist* as a trained professional, often with a postgraduate degree, who is employed in a scientific field. *Citizen scientists* may have received science education or have participated in research, but they are not employed as scientists. The words *scientist* and *researcher* will be used interchangeably in this paper, as will *non-scientist* and *citizen*; in this context, *citizen* refers not to one's personhood, but to one's position as a non-scientist.

Citizen science programs are active in many disciplines, such as astronomy, physics, biochemistry, neuroscience, and more. A simple web search for a citizen science project in any of these fields will yield countless results, as these types of projects have become more popular over the past decade (Pocock, Tweddle, Savage, Robinson, & Roy, 2017). Additionally, citizen science exists in countries across the globe. In the interest of length and clarity, however, the scope of this paper is limited to conservation and environmentally focused citizen science projects within the United States.

For those with greater interest in the topic, we highly recommend reading about the work of the European Citizen Science Association (ECSA), a multinational organization that researches, advocates, and enhances the connection between science and public policy. For those interested in learning about citizen science as it relates to fields outside of the environment and conservation, we recommend visiting SciStarter.com.

Citizen Science: Participatory Research and Analysis

Citizen science is changing the scientific landscape for both the scientific community and the greater public. It can be classified into one of three types: contributive, where citizens gather data; collaborative, where citizens may also analyze or interpret this data; or co-created, where citizens participate in all levels of a project, from designing the question to analyzing data (Follett & Strezov, 2015). In this paper, we are discussing contributive and collaborative citizen science, where both citizens and scientists have input on a project.

Contributive and collaborative citizen science allows experiments, explorations, or inquiries to run on a large-scale, ongoing basis, which provides scientists with large and diverse data sets that might have been otherwise unavailable. (While it is true that many research projects take place over long periods even without citizen science participation, the large-scale volunteer efforts of citizen scientists allow rapid scaling for relatively little capital; Bishop, 2014; Garbarino & Mason, 2016.) Additionally, it gives opportunity for two-way engagement between the public and scientists, can lead to increased topical literacy in participants, and has the capacity to influence policy and decision-making at a range of scales, including, for example, conservation efforts (Mitchell et al., 2017).

Data suggests participation in citizen science helps improve literacy and understanding among members of the public (Cronje, Rohlinger, Crall, & Newman, 2011; Bonney et al., 2009). In many cases, participants come away with a greater appreciation and understanding of the scientific process and their comprehension of the topic they are researching. However, there is no evidence that citizen science participants improve in all areas of science; their knowledge gains may be limited to the areas of research they participated in. Still, members of the public who participate in a citizen science project report higher confidence in their abilities than those who had not previously participated and a higher willingness to participate again (Lewandowski, Caldwell, Elmquist, & Oberhauser, 2017).

Kids in the Dragonfly Detectives program monitor dragonfly mating and migration patterns.

Non-scientists working on conservation-related projects may be likely to take a personal interest in the work. Especially when working on a local project—for example, monitoring insects at a nearby pond—participants can become invested in protecting and learning more about the ecosystem. Over time, they may develop a feeling of ownership and responsibility toward the data being collected (Bonney, Phillips, Ballard, & Enck, 2015). This can also lead to participants gaining a deeper understanding of relationships and interactions in nature, such as how insects can serve as indicators of climate change (Goforth, 2017; Heino, Virkkala, & Toivonen, 2009) or how urban congestion affects air quality (Zhang & Batterman, 2013).

Scientists also benefit greatly from the contributions of citizen scientists. A citizen science network enables researchers to view and utilize data from myriad subjects in locations across the world, all at once. This is perhaps one of the greatest benefits of citizen science: not only do citizen scientists provide usable data, but they can analyze it, too. Due to time and resource constraints, it is often unfeasible for scientists to collect and analyze such large data sets on their own (Chatzigeorgiou et al., 2016).

Citizen science can benefit whole societies and communities, as well. The results of research gained through citizen science projects have been used to inform local policies, enhance formal and informal education initiatives, and conserve natural resources and support environmental sustainability.

The process can be incredibly welcoming to individuals without a scientific background, as long as they have the time or the tools. For example, a bioblitz may require no more than an hour of a person's time at a designated site, and an ID app such as iNaturalist requires nothing more than access to a phone. Many conservation projects are observation based and available through phone apps, including NASA's GLOBE Observer and Mosquito Habitat Mapper, the entire Zooniverse suite, and eBird.

Case Studies from Science Connected

Science Connected is a 501(c)(3) nonprofit publisher whose staff and volunteers author science nonfiction for a general audience. The articles, images, and educational materials that Science Connected produces are the result of a two-way communication between journalists and scientists. In order to write about any topic for the flagship magazine published by Science Connected (GotScience.org), the writers conduct primary and secondary source research, which can include reading press releases, reading peer reviewed published articles, watching videos, conducting interviews, and in some cases participating in events or using a product. The examples that follow are the results of this research.

Tracking Biodiversity

PlantNet is a citizen science project and an app that analyzes user-uploaded images to recognize up to 13,000 species around the world. It uses crowdsourced data to provide users with both the common and scientific names of plants, as well as online resources about those species. The backers of the project are "labs working on either botanical or computer sciences," according to

Rémi Knaff, a community manager for the project. “They are public institutions researching biodiversity, ecology, and deep-learning for information technologies.”

“You don’t need to be an expert in botanical sciences to use the app,” says Knaff. “It was made to be easily used by everyone. Knowledge is power. If you know what’s growing around you, you will be able to protect it better” (Stone, 2017, Who is behind the Pl@ntNet project?).

Another citizen science project, iNaturalist, also crowdsources data to help users identify numerous species, from plants to fungi to birds to mammals. Users search through data uploaded by others and offer their expertise to help provide identification information. Once another user has confirmed an ID is correct, the data may be considered research grade, as long as a quality photo accompanied the identification.

Apps like PlantNet and iNaturalist allow citizen scientists to learn more about their local environments and become more engaged with the world around them, all while contributing to valuable research. At the same time, several metrics from numerous data sets are being tracked, recorded, and made available, helping scientists from countless organizations and labs find information suitable for their research.

Volunteers from the Friends of Sausal Creek rebuild damaged habitats to help native species thrive.

Other programs such as the Friends of Sausal Creek project based in Oakland, California, have more immediate impacts on biodiversity. They use citizen science to restore eroded watersheds, depleted pollinator populations, and native flora. They also work with the local water board to monitor chemical runoff.

One of their greatest tasks is removing invasive species and replacing them with natives. “A landscape of native plants typically has a good deal of biodiversity, and therefore supports a wider variety of fauna,” according to the program’s executive director, Kimra McAfee.

> The [nonnatives, including] ivy and Himalayan blackberry tend to take over large swatches of land, so biodiversity of flora and fauna is greatly diminished. The nonnative landscapes don’t support the pollinators, especially the native bees, like the diverse native flora does. (K. McAfee, personal communication, October 29, 2017)

Volunteers from the town and from local schools help monitor the parks for invasives. They regularly meet to remove the nonnative plants, and they maintain a nursery of native species to repopulate the landscape. A volunteer has catalogued all of the native plants in the area, and has also entered the names of the plants in the citizen science database CalFlora.

“One indicator of the fruits of our work in increasing biodiversity is the increase in bird species found in our bird monitoring. Our 2003 bird checklist had 92 species; our 2016 update had 129 species!” (K. McAfee, personal communication, October 29, 2017).

Protecting Endangered Species

Government, research, and nonprofit organizations often collaborate to oversee and uphold the rules set forth by the United States Endangered Species Act (Jain, 2016). The act has over 1,600 animals listed as endangered, all of which require long-term interventions to ensure their survival. Researchers from dozens of organizations rely on each other and on outside data to manage the daunting task of tracking the 1,600 species officially listed as endangered, while also tracking the thousands of other species living in difficult situations. One strategy they use to monitor the listed species is to use data gathered from citizen science projects, which helps allay costs and save resources. Making this strategy more appealing is that federal scientists often participate in, or even initiate, citizen science projects (Evans et al., 2016).

The National Oceanic and Atmospheric Administration (NOAA), for example, both directly funds citizen science projects (through its Sea Grant program) and facilitates a database for crowdsourcing large-scale projects. It is a member of the Federal Community of Practice for Crowdsourcing and Citizen Science, which helps federal scientists establish and proceed with their citizen science projects (NOAA, 2018). Similarly, the U.S. Forest Service (USFS) offers funding of up to $25,000 for eligible citizen science projects related to resource management. Their detailed guidelines suggest that in addition to providing a genuine scientific outcome, the collaborative and educational aspects of citizen science are crucial for a project's success. Additionally, National Science Foundation (NSF) grants are being awarded to citizen science projects on an increasingly regular basis (2018).

HerpMapper is another citizen science project that shares its information with state and federal agencies, nongovernmental organizations, and universities for research, conservation, and preservation purposes. They have over 50 partnerships, including with various branches of the U.S. Fish and Wildlife Service, the USFS, and the U.S. Geological Survey.

"The data [we collect] are used to develop species distribution maps, determine habitat associations, take in-species status assessments, identify road-mortality hotspots, create niche modeling, and more," says Christopher Smith, a project administrator with HerpMapper (personal communication, October 21, 2017). Scientists and citizens both participate in the project, and accuracy is maintained with a vigorous screening process that includes user flagging, board administrators and partners, and a taxonomic committee.

HerpMapper is aware that data sharing can have potential consequences, not only for the participants of a citizen science project but also for the species it targets.

> One of the unforeseen consequences of online data collection and sharing is poaching. . . . In order to minimize potential impacts to herpetofaunal populations in their habitats, HerpMapper has opted to obscure all observations—not just rare species—to the county level in the US and to an equivalent scale elsewhere. The focus on protecting the resource first, and providing data in as safe a way as possible, has been a major reason for HerpMapper's success. (C. Smith, personal communication, October 21, 2017)

While many citizen science projects outsource data to organizations that create or enforce conservation policy, others, including Rescue a Reef, based at the University of Miami, Florida, use the power of public participation to conserve local resources. Like corals all over the world, Florida's reefs have experienced mass bleaching events and other threatening conditions that have led to decline. Across the world, some reefs have lost up to 95% of their populations. The Miami reefs contain over 50 species of coral and more than 100 types of fish, so restoring the degraded reefs is essential to maintaining the rich ecosystem ("What Is Rescue a Reef?" 2018).

Volunteer divers transplant coral colonies with the citizen science project Rescue a Reef.

Rescue a Reef is a program in which researchers cultivate coral and train local volunteers to plant the pups on the degraded reefs. With the help of citizen participants, Rescue a Reef has been able to plant new coral and has reported a success rate of over 80% (D. Hesley, personal communication, May 2017; Lirman et al., 2010). Volunteer divers, after receiving training from the experts at the university, were just as successful as the scientists (even more so, in some cases), and they came away learning about the importance of the reef for their community and the shoreline ecosystem. Many participants repeatedly volunteer, as they become engaged with the idea of restoring their environment.

“We already knew there was educational value associated with our restoration efforts,” said Dalton Hesley, a research associate with the program. “Our results highlighted that citizen scientists can be trained to our practitioner-level standards.”

Share the Benefits of Citizen Science

Citizen science is an effective partnership between scientists and nonscientists that, when done well, offers benefits to the participants and beyond. Scientists can gain valuable data, analysis, and assistance in performing high-level procedures; citizens can gain essential understanding of their environments and increased scientific literacy. Perhaps most important, countless species and habitats benefit from the large-scale, collective efforts that citizen science makes possible.

For those interested in running or participating in citizen science, we recommend the following publications.

Australian Guide to Running a BioBlitz

http://www.ala.org.au/wp-content/uploads/2011/10/BIOBLITZ_Guidelines_WEB-final-201507.pdf

Choosing and Using Citizen Science: A Guide to When and How to Use Citizen Science to Monitor Biodiversity and the Environment

https://www.ceh.ac.uk/sites/default/files/sepa_choosingandusingcitizenscience_interactive_4web_final_amended-blue1.pdf

Doing It Together Science: A Collection of Citizen Science Guidelines and Publications

https://ecsa.citizen-science.net/blog/collection-citizen-science-guidelines-and-publications

Federal Crowdsourcing and Citizen Science Toolkit
https://www.citizenscience.gov/toolkit/

Guide to Citizen Science: Developing, Implementing and Evaluating Citizen Science to Study Biodiversity and the Environment in the UK

http://www.nhm.ac.uk/content/dam/nhmwww/take-part/Citizenscience/citizen-science-guide.pdf

White Paper on Citizen Science for Europe

http://www.socientize.eu/sites/default/files/white-paper_0.pdf

References

Aswani, S., & Lauer, M. (2006). Incorporating fishermen's local knowledge and behavior into geographical information systems (GIS) for designing marine protected areas in Oceania. *Human Organization*, *65*(1), 81–102. doi:10.17730/humo.65.1.4y2q0vhe4l30n0uj

Bishop, S. (2014, October 1). Citizen science is stimulating a wealth of innovative projects. *Scientific American*. Retrieved from https://www.scientificamerican.com/article/citizen-science-is-stimulating-a-wealth-of-innovative-projects/

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience*, *59*(11), 977–984. doi:10.1525/bio.2009.59.11.9

Bonney, R., Phillips, T., Ballard, H., & Enck, J. (2015). Can citizen science enhance public understanding of science? *Public Understanding of Science. 25*(1), 2–16. https://doi.org/10.1177/0963662515607406

Chatzigeorgiou, G., Faulwetter, S., Dailianis, T., Smith, V., Koulouri, P., Dounas, C., & Arvanitidis, C. (2016). Testing the robustness of citizen science projects: Evaluating the results of pilot project COMBER. *Biodiversity Data Journal*, (4), e10859. Advance online publication. http://doi.org/10.3897/BDJ.4.e10859

Citizen science toolkit: Teaching science through citizen science [Pamphlet]. (2015). San Francisco, CA: California Academy of Sciences. https://www.calacademy.org/sites/default/files/assets/docs/pdf/cascitizensciencetoolkit_forweb_v2.pdf

Cornell Lab of Ornithology. (n.d.). Where birds come to life. Retrieved May 2, 2018, from https://nestwatch.org/

Cronje, R., Rohlinger, S., Crall, A., & Newman, G. (2011). Does participation in citizen science improve scientific literacy? A study to compare assessment methods. *Applied Environmental Education & Communication*, *10*(3), 135–145. doi:10.1080/1533015x.2011.603611

Dale, A., & Armitage, D. (2011). Marine mammal co-management in Canada's Arctic: Knowledge co-production for learning and adaptive capacity. *Marine Policy*, *35*(4), 440–449. doi:10.1016/j.marpol.2010.10.019

Danielsen, F., Jensen, P. M., Burgess, N. D., Altamirano, R., Alviola, P. A., Andrianandrasana, H., . . . Young, R. (2014). A multicountry assessment of tropical resource monitoring by local communities. *BioScience, 64*(3), 236–251. doi:10.1093/biosci/biu001

Evans, D., Che-Castaldo, J., Crouse, D., Davis, F., Epanchin-Niel, R., Flather, C., . . . Williams, B. (2016). Species recovery in the United States: Increasing the effectiveness of the Endangered Species Act. *Issues in Ecology, 6*, 1–29. http://www.esa.org/esa/wp-content/uploads/2016/01/Issue20.pdf

Federal crowdsourcing and citizen science toolkit. (n.d.). Retrieved February 6, 2018, from https://www.citizenscience.gov/toolkit/

Follett, R., & Strezov, V. (2015). An analysis of citizen science based research: Usage and publication patterns. *PLoS ONE, 10*(11). doi:10.1371/journal.pone.0143687

Freitag, A., Meyer, R., & Whiteman, L. (2016). Correction: Strategies employed by citizen science programs to increase the credibility of their data. *Citizen Science: Theory and Practice, 1*(2). doi:10.5334/cstp.91

Garbarino, J., & Mason, C. E. (2016). The power of engaging citizen scientists for scientific progress. *Journal of Microbiology & Biology Education, 17*(1), 7–12. http://doi.org/10.1128/jmbe.v17i1.1052

Goforth, C. (2017, March). *Dragonfly Detectives*. Presentation at the Citizen Science Association Conference.

Heino, J., Virkkala, R., & Toivonen, H. (2009). Climate change and freshwater biodiversity: Detected patterns, future trends and adaptations in northern regions. *Biological Reviews of the Cambridge Philosophical Society*, *84*(1), 39–54.

Jain, N. (2016, February 18). Strengthening the Endangered Species Act. Retrieved from https://www.gotscience.org/2016/02/strengthening-the-endangered-species-act/

Keyles, S. (2017, September 7). How can kids become citizen scientists? Retrieved from https://www.gotscience.org/2017/09/can-kids-become-citizen-scientists/

Lewandowski, E., Caldwell, W., Elmquist, D., & Oberhauser, K. (2017). Public perceptions of citizen science. *Citizen Science: Theory and Practice*, *2*(1), 3. http://doi.org/10.5334/cstp.77

Lirman, D., Thyberg, T., Herlan, J., Hill, C., Young-Lahiff, C., Schopmeyer, S., . . . Drury, C. (2010). Propagation of the threatened staghorn coral *Acropora cervicornis*: Methods to minimize the impacts of fragment collection and maximize production. *Coral Reefs*, *29*(3), 729–735. https://doi.org/10.1007/s00338-010-0621-6

Mitchell, N., Triska, M., Liberatore, A., Ashcroft, L., Weatherill, R., & Longnecker, N. (2017). Benefits and challenges of incorporating citizen science into university education. *PLoS ONE*, *12*(11), e0186285. doi:10.1371/journal.pone.0186285

National Science Foundation: Where discoveries begin. (n.d.). Retrieved January 30, 2018, from https://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=136445

NOAA. (n.d.). Citizen science and crowdsourcing. Retrieved May 2, 2018, from http://www.noaa.gov/office-education/citizen-science-crowdsourcing

Pocock, M., Tweddle, J., Savage, J., Robinson, L., & Roy, H. (2017). The diversity and evolution of ecological and environmental citizen science. *PLoS ONE, (12)*4, e0172579. https://doi.org/10.1371/journal.pone.0172579

Sagan, C. (1990). Why we need to understand science. *The Skeptical Inquirer*, *14*(3).

Starr, J., Schweik, C. M., Bush, N., Fletcher, L., Finn, J., Fish, J., & Bargeron, C. T. (2014). Lights, camera…citizen science: Assessing the effectiveness of smartphone-based video training in invasive plant identification. *PLoS ONE*, *9*(11), e111433. doi:10.1371/journal.pone.0111433

Stone, K. (2017, September 21). Citizen scientists invited to identify plants. Retrieved from https://www.gotscience.org/2017/09/citizen-scientists-identify-plants/

What is Rescue a Reef? (n.d.). Retrieved February 6, 2018, from https://sharkresearch.rsmas.miami.edu/donate/rescue-a-reef

Zhang, K., & Batterman, S. (2013). Air pollution and health risks due to vehicle traffic. *Science of The Total Environment*, *450–451*, 307–316. doi:10.1016/j.scitotenv.2013.01.074

About Science Connected

We started Science Connected back in 2015 with a brand new model and crystal clear dream— to shake up the way science is shared with the greater public. We work with scientists and educators to provide children with the scientific knowledge that will help them become the citizens, leaders, and innovators of tomorrow. We also work with researchers, journalists, and universities to provide cutting-edge research findings to learners of all ages.

We are a 501(c)(3) nonprofit organization headquartered in San Francisco, California. Our work is funded by grants and donations from the Clif Bar Family Foundation, Google, the Pollination Project, Awesome Without Borders, and individuals who care about accessible science education.

Contact Us

Science Connected

P.O. Box 190213
San Francisco CA 94119 USA

www.scienceconnected.org

info@scienceconnected.org

https://www.facebook.com/scienceconnected/

https://www.instagram.com/gotsciencemagazine/

https://twitter.com/gotscienceorg

Acknowledgements

Science Connected would like to thank the following people for providing peer review feedback on this publication:

Bina Vanmali

Jason M. Organ

Jennifer Lynn Shirk

Kelly Derham

Kyle Copas

Cornelia Veja

Nicola Moczek

Oliviero Spinelli

Pen-Yuan Hsing

Sarah West

Steven Spence

Tara Shirazi

V. Juliette Cortes

Vickie Curtis