Review on Agriculture and Rural Development 2023 vol. 12 (1-2) ISSN 2677-0792
DOI: 10.14232/rard.2023.1-2.27-36

CONTRIBUTION OF NATURE CONSERVATION RELATED CITIZEN SCIENCE PROJECTS TO LEARNING, ATTITUDE AND BEHAVIORAL CHANGE OF PARTICIPANTS

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Abstract: Nature Conservation related Citizen Science (NCCS) is an emerging area of research and practice where volunteers take part in a scientific process, usually focusing on data gathering or monitoring for conservation purposes. We present a review of studies where questionnaire surveys were used to measure the impacts of NCCS projects on the learning, attitude and behavioral change of volunteers before or after their participation in the projects. Our results show that many NCCS projects have enhanced the learning of participants in different areas (e.g. increasing knowledge about species and recognition of species skills). Participation also affected the attitude of participants toward nature conservation, while attitude toward science was less often reported. When participants showed sympathy and appreciation for nature or species, in some cases it led to conservation action. Common characteristics of the NCCS projects that resulted inhigher impacts on learning/knowledge, attitude and behavior, included the development of well-designed learning plans, interactions during and after participation, building trust and establishing partnerships and collaboration. These can be used as recommendations for further development of NCCS project.

Keywords: citizen science, nature conservation, questionnaire survey, review

1. Introduction

Citizen science (CS) is any activity where members of the public contribute voluntarily to different stages of the scientific process and scientific data are gathered (Bonney et al., 2014). Scientists and practitioners started to see the potential of CS as a practical way to undertake research in places and at scales that would not have been possible otherwise (Bonney, 2021; Szép & Gibbons 2000). Properly executed CS supports not just scientific endeavors, but also policy-making (Hochkirch et al. 2013), engagement of citizens and nature conservation (McKinley et al. 2017). It also benefits participants, e.g. by enhancing individual skills or learning (Bonney et al. 2009; Bela et al. 2016; Bíl et al. 2020; Balázs et al. 2021). According to McKinley et al. (2017), CS is becoming a promising option for tackling environmental challenges in the fields of conservation biology, natural resource management and environmental conservation. Nature Conservation-related Citizen Science (NCCS) projects usually focus on gathering data about biodiversity, distribution and abundance of species or natural resources (Follett & Strezov 2015; Chandler et al. 2017; Pocock et al. 2017). The number of NCCS projects has risen over the past few years (Pocock et al. 2017), and with them, the number of studies that explore their impacts, e.g. the effectiveness of the use of CS data in biodiversity research

(Chandler et al. 2017), conservation outcomes of CS (McKinley et al. 2017), the contribution of CS to the sustainable development goals (Moczek et al. 2021; Criscuolo et al. 2023) and using CS data in conservation policy and decision-making (European Commission et al. 2018; Young et al. 2019). These studies covered the opinions of scientists and experts that managed the projects but it seemed necessary to assess the perceptions of participants as well (Kieslinger et al. 2017). Participating in NCCS projects can have an impact on participant outcomes linked to interest, awareness, knowledge, learning, skills, engagement, attitude or behavior (Clayton & Myers 2015; Dietsch et al. 2020) since they entail direct or indirect connection with nature (Friedman et al. 2008). Our review aims to explore studies where surveys were used to measure the impacts of NCCS projects on learning/knowledge, attitude and behavioral change of volunteers during or after their participation. We attempt to identify the common characteristics of the NCCS projects as well, which can be used as recommendations for further development of NCCS projects.

2. Materials and methods

A literature review was conducted using the Web of Science, Google Scholar and Scopus as the main search engines. We used the Boolean operators as allowed by each database, “AND” and “OR were used for terms combinations needed and quotation marks (“”) were added when looking for exact combined phrases (e.g. “citizens science”, “nature conservation”). We did not apply chronological restrictions when searching. We formulated the primary search equation: ("citizen science” or "community science”) and (nature or conservation or biodiversity) and (attitude or learning or knowledge or behavior). Some variations were needed for the Scopus search to avoid errors, so we added parentheses at the beginning and end of the same search equation. In the review, we included only studies of citizen science projects related to nature conservation, biodiversity or species. From the selected papers, we chose studies where self-filling questionnaire surveys were used to measure the impacts of NCCS projects on the learning/knowledge, attitude and behavioral change of volunteers before or after their participation in the projects. Altogether 25 studies were chosen for the review. Most of them assessed one NCCS project, except for four studies that surveyed participants of multiple NCSS projects. We conducted a content analysis (Stemler, 2001) using 8 a priori codes based on the framework on citizen scientists’ outcomes proposed by Phillips et al. (2018), but we modified it by adding attitude (Friedman et al. 2008; Peter et al. 2019) instead of interest and motivation (*Table 1*). In addition, we also used emergent codes for the common characteristics of successful projects.

Table 1: A priori codes for the analysis of NCCS projects

Category	Code
Learning/Knowledge: A learning process that results in the acquisition of new knowledge or skills that increases the literacy of individuals.	1. knowledge about nature and ecology
	2. knowledge about species
	3. species recognition skills
	4. knowledge about conducting scientific research
Attitude: a settled way of thinking or feeling about something.	5. attitude toward science
	6. attitude toward nature
Behavior: Measurable actions resulting from engagement in NCCS projects but different from the project protocol activities.	7. pro-nature conservation behavior
	8. behavior related to science

Source: Based on Phillis et al. (2018) modified

3. Results

In the 25 studies bees and pollinators were the most common target species of NCCS projects (12), but there were projects focusing on land crabs, sea lions, coral, urban baths, owls, monarch butterflies, native fish and freshwater turtles as well. There were only two projects about plant species and three about biodiversity in general. Half of the surveys were conducted after the project and half were applied before and after the project. In 31% of the surveys, the three impact categories (knowledge/learning, attitudes and behavior) were assessed together, in 32% of the surveys two impact categories, and in 37% of surveys only one category was investigated (*Table 2*).

3.1. Impact of NCCS projects on learning/knowledge of participants

In the category of learning/knowledge, the impact of NCCS projects on knowledge about target species was reported in most studies followed by the impact on species recognition skills (skills development or skills reinforcement). The impact on knowledge about nature and ecology and conducting scientific research was shown in much less studies (*Table 2*). Even though participants went through a learning process in most of the projects, it seems that their understanding of nature and scientific processes remained the same. NCCS projects that included educational resources such as supplementary materials, phone apps with interactive information features and/or dynamic training, supported the learning process of participants in most of the CS initiatives. Additionally, social interaction between project staff and volunteers, as well as feedback, seems to help reinforce the learning experience, which holds considerable potential for improving the learning environment and scientific literacy (Meschini et al. 2021; Christ et al. 2022; Nadkarni et al. 2022).

Table 2: A priori codes for the analysis of NCCS projects.

Reference		Category surveyed	Impacts							
			Knowledge/ Learning				Attitude		Behavior	
			1. knowledge about nature and ecology	2. knowledge about species	3. species recognition skills	4. knowledge about conducting scientific research	5. attitude toward science	6. attitude toward nature	7. pro nature conservation behavior	8. behavior related to science
1	Day et al. (2022)	K	x							
2	Sturm et al. (2021)	A / B						x	x	
3	Jordan et al. (2011)	K / A / B	x	x	x			x	x	
4	Pocock et al. (2023)	A / B						x		
5	White et al. (2023)	A						x		
6	Chao et al. (2021)	K / A / B	x		x		x	x	x	
7	Sakurai et al. (2022)	K / B		x						
8	Peter et al. (2021)	K / A / B			x		x	x	x	
9	Santori et al. (2021)	K / A / B		x				x	x	
10	Peter et al. (2021)	K		x	x			x	x	
11	Nadkarni et al. (2022)	K	x			x				
12	Kountoupes & Oberhauser (2008)	K / A		x			x	x		x
13	Carson et al. (2021)	K / A			x	x		x		
14	Phillips et al. (2021)	K / A / B		x	x			x		
15	Christ et al. (2022)	K / A / B	x	x						
16	Brossard et al. (2005)	K / A		x						
17	Sharma et al. (2019)	K / B		x	x			x		
18	Meschini et al. (2021)	K								
19	Ganzevoort & van den Born (2020)	A						x		
20	Ng et al. (2018)	A / B	x					x		
21	Hsu et al. (2019)	K / A / B		x				x	x	
22	Greving et al. (2022)	K / A		x			x			
23	Weisberg et al. (2023)	K / A		x		x		x		
24	MacPhail et al. (2020)	K / A			x			x		
25	Ganzevoort & van den Born (2021)	K / A / B		x				x	x	

Source: own compilation

3.2. Impact of NCCS projects on the attitude of participants

Within the category of attitude, impact on the attitude toward nature was reported in more studies than impacts on attitude toward science (*Table 2*). For example, a change in attitude was observed among participants of a NCCS project related to pollinators. Some respondents were afraid of bees before joining the project.

However, their attitudes changed positively after participation, and they started to value the ecological importance of the species (Christ et al. 2022). Positive emotions (e.g. joy, happiness, sympathy) toward species or nature not only resulted in a positive attitude toward nature but in some cases, they also led to actions (Ng et al. 2018; Sturm et al. 2021; Peter et al. 2021; Santori et al. 2021; Carson et al. 2021).

3.3 Impact of NCCS projects on the behavioral change of participants

Within the category of behavior, a positive change to pro-nature behavior as a result of participation in an NCCS project was reported in much more studies than the change in behavior related to science. Some studies considered participation in the survey itself as a pro-nature behavior, while other studies regarded only specific actions as pro-nature conservation behavior, e.g. restoring habitats of animal species (Santori et al. 2021), replacing invasive plant species with native ones in private gardens (Ganzevoort & van den Born 2021; Peter et al. 2021), talking about the species and the NCCS project with other people (Jordan et al. 2011; Ganzevoort & van den Born 2020; Ganzevoort & van den Born 2021;). In some other cases, people became more mindful of their waste and started to collect trash when they were doing outdoor activities in nature (Jordan et al. 2011; Ganzevoort & van den Born 2021; Peter et al. 2021; Chao et al. 2021, Day et al. 2022).

3.4 Characteristics of nature conservation citizen science projects

The following characteristics that contributed to the successful impacts of projects in many impact categories were usually related to project design: strategies to approach participants, communication channels, social interactions and collaborations. Having well-designed learning plans and including them in diverse ways in knowledge transfer and training (e.g. providing printed materials for species recognition, apps that guided the participants to perform the required activities, and personalized training that provided opportunities to interact with experts) helped to enhance the learning of participants. When the projects promoted social interactions among the participants, it was often reported that the experiences were useful for them and deepened their connection with nature. They started to talk more about the projects and even invited people to join. This resulted in a change in attitude which in many cases led to conservation actions. Building trust between experts and participants seemed to be useful for maintaining the continuity of participation of volunteers in the projects, and it also contributed to the increase in knowledge. The common trust-building strategies included providing individual feedback, sending invitations for events, developing different forms of recognition or sending reminder messages about activities. In this way, they promoted a sense of valorization of volunteers' work which influenced the attitude of participants and resulted in the continuation of participation. The contribution of various partners from different fields and organizations was another characteristic that affected knowledge/learning, attitude and behavior. For example, some projects were run through school programs. The teachers helped to build trust between the project staff and students

and also assisted the scientists in training the students. It was useful to ensure the reliability of the data collected as well as to enhance the knowledge of participants.

4. Discussion

Evaluation of CS project outcomes is important for project decision-making (Jordan et al. 2012). Kieslinger et al. (2017) stress that to fully understand the impacts of NCCS, the perception of different actors needs to be assessed. Bela et al. (2016) found a lack of studies that evaluate CS impacts, while our review indicates an increasing number of studies focusing on the transformative effects of CS projects related to learning/knowledge, attitude and behavior in recent years. Haywood et al. (2016) showed in their earlier study that citizen science initiatives improved the general knowledge of nature among participants. In our review, more studies reported changes in knowledge about species and species recognition than in knowledge about nature and ecology. Besides participation, a focused educational plan, promoting participants and project staff interaction, establishing training sessions, showing recognition, and giving feedback, can also assist in gaining better learning/knowledge outcomes (Jordan et al. 2011; Shah & Martinez 2016). According to our research findings, there were only a few studies that reported a change in attitude toward science. Several authors have argued that deeper attitudinal shifts toward science would require involvement in more phases of the research process (Bonney et al. 2009; Haklay, 2013; Shah & Martinez 2016). Promoting methodologies that involve participants in contributory experiences and in more than one activity of the research process might help to increase science-related impacts. How people perceive, enjoy, feel, understand and describe nature, can influence attitude changes which can encourage positive behaviors toward nature conservation (Peter et al. 2019, Hatty et al. 2022). When participants of the analyzed NCCS projects reported emotions (e.g. joy, happiness, sympathy), it had an impact on their attitude which encouraged them to take pro-nature actions. In general, our findings show that pro-nature behavior was more frequently reported than behavior related to science. However, it is noteworthy that most of the studies examined focused on NCCS initiatives that involved tracking charismatic and well-liked species such as pollinators, turtles, birds and butterflies. It would be interesting to investigate how citizen science initiatives that concentrate on less charismatic species affect participants' behavior. Previous studies that investigated features of CS projects found that training provided, cooperativeness among volunteers and communication potentially influenced the development of participants (Peter et al. 2021). Similarly, according to the results of our review, some common characteristics were found to foster higher impacts on learning/knowledge, attitude and behavior, such as the development of well-designed learning plans, the inclusion of social interactions during and after participation, promoting trust, establishing partnerships and collaboration. We propose these characteristics as recommendations that can be used to improve NCCS initiatives.

References

Balázs, B., Mooney, P., Nováková, E., Bastin, L., Jokar J. (2021): Data Quality in Citizen Science. In K. Vohland, A. Land-Zandstra, L. Ceccaroni, R.Lemmens, J. Perelló, M. Ponti, R. Samson, K. Wagenknecht. Springer,Cham, 139–157. DOI: https://doi.org/10.1007/978-3030-58278-4_8

Bela, G., Peltola, T., Young, J. C., Balázs, B., Arpin, I., Pataki, G., Hauck, J., Kelemen, E., Kopperoinen, L., Van Herzele, A.,Keune, H., Hecker, S., Suškevičs, M., Roy, H. E., Itkonen, P., Külvik, M., László, M., Basnou, C.,Pino, J., Bonn, A. (2016): Learning and the transformative potential of citizen science: Lessons from the Study of Nature. Conservation Biology,30(5): 990–999. DOI: https://doi.org/10.1111/cobi.12762

Bíl, M., Heigl, F., Janoška, Z., Vercayie, D., & Perkins, S. E. (2020): Benefits and challenges of collaborating with volunteers: Examples from National Wildlife Roadkill Reporting Systems in Europe. Journal for Nature Conservation, 54: 125798. DOI: https://doi.org/10.1016/j.jnc.2020.125798

Bonney, R. (2021): Expanding the Impact of Citizen Science. BioScience, 71: 448–451. DOI: https://doi.org/10.1093/biosci/biab041

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Philips, T., Shirk, J., & Wilderman, C. (2009): Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE InquiryGroup Report. Washington, D.C.: Center for Advancement of Informal Science Education (CAISE)

Bonney, R., Shirk, J. L., Phillips, T. B., Wiggins, A., Ballard, H. L., Miller-Rushing, A. J., & Parrish, J. K. (2014): Next Steps for Citizen Science. Science, 343: 1436–1437. DOI: https://doi.org/10.1126/science.1251554

Brossard, D., Lewenstein, B., & Bonney, R. (2005): Scientific knowledge and attitude change: The impact of a citizen science project. International Journal of Science Education, 27(9): 1099–1121. DOI:https://doi.org/10.1080/0950 0690500069483

Bruckermann, T., Greving, H., Schumann, A., Stillfried, M., Börner, K., Kimmig, S. E., Hagen, R., Brandt, M., Harms, U. (2021): To know about science is to love it? Unraveling cause–effect relationships between knowledge and attitudes toward science in citizen science on urban wildlife ecology. Journal of Research in Science Teaching, 58(8): 1179–1202. DOI:https://doi.org/10.1002/tea.21697

Carson, S., Rock, J., Smith, J. (2021): Sediments and Seashores—A Case Study of Local Citizen Science Contributing to Student Learning and Environmental Citizenship. Frontiers in Education, 6, 674883. DOI:https://doi.org/10.3389/feduc.2021.674883

Chandler, M., See, L., Copas, K., Bonde, A. M. Z., López, B. C., Danielsen, F., Legind, J. K., Masinde, S., Miller Rushing, A. J., Newman, G., Rosemartin, A.,Turak, E. (2017): Contribution of citizen science towards international biodiversity monitoring. Biological Conservation, 213, 280-294. DOI:https://doi.org/10.1016/j.biocon.2016.09.004

Chao, S.-H., Jiang, J.-Z., Wei, K.-C., Ng, E., Hsu, C.-H., Chiang, Y.-T., Fang, W. T. (2021): Understanding Pro Environmental Behavior of Citizen Science:An Exploratory Study of the Bird Survey in Taoyuan's Farm Ponds Project. Sustainability, 13(9),5126.DOI:https://doi.org/10.3390/su13095126

Christ, L., Hahn, M., Sieg, A.-K., Dreesmann, D. (2022): Be(e) Engaged! How Students Benefit from an Educational Citizen Science Project on Biodiversity in Their Biology Classes. Sustainability, 14(21), 14524. DOI:https://doi.org/10.3390/su142114524

Clayton, S., & Myers, G. (2015): Understanding and Promoting Human Care for Nature. Conservation Psychology. Criscuolo, L., L'Astorina, A., van der Wal, R., Gray, L. C. (2023): Recent contributions of citizen science on sustainability policies: A critical review. Current Opinion in Environmental Science & Health, 31, 100423. DOI:https://doi.org/10.1016/j.coesh.2022.100423

Day, G., Fuller, R. A., Nichols, C., & Dean, A. J. (2022): Characteristics of immersive citizen science experiences that drive conservation engagement. People and Nature, 4(4), 983–995. DOI:https://doi.org/10.1002/pan3.10332

Dietsch, A. M., Wallen, K. E., Clayton, S., Kretser, H. E., Kyle, G. T., Ma, Z., Vercammen, A. (2020): Introduction: New directions in conservation psychology at a critical time. Conservation Biology, 34(6), 1335–1338. DOI:https://doi.org/10.1111/cobi.13629

European Commission., Bio Innovation., Fundación Ibercivis., The Natural History Museum. (2018): Citizen science for environmental policy: Development of an EU wide inventory and analysis of selected practices. Publications Office. https://data.europa.eu/doi/10.2779/961304

Follett, R., & Strezov, V. (2015): An Analysis of Citizen Science Based Research: Usage and Publication Patterns. PLOS ONE, 10(11), e0143687. DOI:https://doi.org/10.1371/journal.pone.0143687

Friedman, A., David A. Ucko, Allen, S., Patricia B. Campbell, Lynn D. Dierking, Flagg, B. N., Alan J. Friedman, Cecilia Garibay, Randi Korn, & Gary Silverstein. (2008): Framework for Articulating and Measuring Individual Learning Outcomes from Participation.https://www.tamucc.edu/research/researchengagement/ore/assets/documens/bi_library/broder-impacts-eval-framework.pdf

Ganzevoort, W., Van Den Born, R. J. G. (2020): Understanding citizens' action for nature: The profile, motivations and experiences of Dutch nature volunteers. Journal for Nature Conservation, 55: 125824. DOI:https://doi.org/10.1016/j.jnc.2020.125824

Greving, H., Bruckermann, T., Schumann, A., Straka, T. M., Lewanzik, D., Voigt Heucke, S. L., Marggraf, L., Lorenz, J., Brandt, M., Voigt, C. C., Harms, U., Kimmerle, J. (2022): Improving attitudes and knowledge in a citizen science project about urban bat ecology. Ecology and Society, 27(2): 24.DOI:https://doi.org/10.5751/ES13272-270224

Haklay, M. (2013): Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation. In D. Sui, S. Elwood, & M. Goodchild (Eds.), Crowdsourcing Geographic Knowledge. Springer, 105122). DOI:https://doi.org/10.1007/978-94-007-4587-2_7

Hatty, M., Goodwin, D., Smith, L., Mavondo, F. (2022): Speaking of nature: Relationships between how people think about, connect with, and act to protect nature. Ecology and Society, 27: 3. DOI:https://doi.org/10.5751/ES13369-270317

Haywood, B. K., Parrish, J. K., Dolliver, J. (2016): Place-based and data-rich citizen science as a precursor for conservation action: Citizen Science and Conservation Action. Conservation Biology, 30: 476–486. DOI:https://doi.org/10.1111/cobi.12702

Hochkirch, A., Schmitt, T., Beninde, J., Hiery, M., Kinitz, T., Kirschey, J., Matenaar, D., Rohde, K., Stoefen, A., Wagner, N., Zink, A., Lötters, S., Veith, M., Proelss, A. (2013): Europe Needs a New Vision for a Natura 2020 Network Conservation Letters, 6: 462-467. DOI:https://doi.org/10.1111/conl.12006

Hsuan, C.H., Chang, Y.M., Liu, C.-C. (2019): Can Short-Term Citizen Science Training Increase Knowledge, Improve Attitudes, and Change Behavior to Protect Land Crabs? Sustainability, 11: 391-398. DOI:https://doi.org/10.3390/su1114391

Jordan, R. C., Gray, S. A., Howe, D. V., Brooks, W. R., Ehrenfeld, J. G. (2011): Knowledge Gain and Behavioral Change in Citizen-Science Programs: Citizen-Scientist Knowledge Gain. Conservation Biology, 25(6): 1148 1154. DOI:https://doi.org/10.1111/j.1523-1739.2011.01745.x

Jordan, R. C., Ruibal-Villasenor, M., Hmelo-Silver, C. E., Etkina, E. (2011): Laboratory materials: Affordances or constraints? Journal of Research in Science Teaching, 48(9): 1010–1025. DOI:https://doi.org/10.1002/tea.20418

Jordan, R. C., Ballard, H. L., Phillips, T. B. (2012): Key issues and new approaches for evaluating citizen-science learning outcomes. Frontiers in Ecology and the Environment, 10(6): 307–309. DOI:https://doi.org/10.1890/110280

Kieslinger, B., Schäfer, T., Heigl, F., Dörler, D., Richter, A., Bonn, A. (2017): The Challenge of Evaluation: An Open Framework for Evaluating Citizen Science Activities. SocArXiv.DOI:https://doi.org/10.17605/OSF.IO/ENZC9

Kountoupes, D., & Oberhauser, K. (2008): Citizen Science and Youth Audiences: Educational Outcomes of the Monarch Larva Monitoring Project. Journal of Community Engagement, 1: 10–20.

MacPhail, V. J., Gibson, S. D., Colla, S. R. (2020): Community science participants gain environmental awareness and contribute high quality data but improvements are needed: Insights from Bumble Bee Watch. PeerJ, 8:9141. DOI:https://doi.org/10.7717/peerj.9141

Meschini, M., Prati, F., Simoncini, G. A., Airi, V., Caroselli, E., Prada, F., Marchini, C., Machado Toffolo, M., Branchini, S., Brambilla, V., Covi, C., Goffredo, S. (2021): Environmental Awareness Gained During a Citizen Science Project in Touristic Resorts Is Maintained After 3 Years Since Participation. Frontiers in Marine Science, 8: 584-644. DOI:https://doi.org/10.3389/fmars.2021.584644

McKinley, D. C., Miller-Rushing, A. J., Ballard, H. L., Bonney, R., Brown, H., Cook-Patton, S. C., Evans, D. M., French, R. A., Parrish, J. K., Phillips, T.B., Ryan, S. F., Shanley, L. A., Shirk, J. L., Stepenuck, K. F., Weltzin,J.F.,Wiggins, A., Boyle, O. D., Briggs, R. D., Chapin, S. F.,Soukup, M. A. (2017): Citizen science can improve conservation science, natural resourcemanagement, and environmental protection. Biological Conservation,208: 15–28. DOI:https://doi.org/10.1016/j.biocon.2016.05.015

Moczek, N., Voigt-Heucke, S. L., Mortega, K. G., Fabó Cartas, C., Knobloch, J. (2021): A Self-Assessment of European Citizen Science Projects on Their Contribution to the UN Sustainable Development Goals (SDGs). Sustainability, 13(4): 1774. DOI:https://doi.org/10.3390/su13041774

Nadkarni, N., Chen, J., Morris, J., Carriero, A., Kaye, T., Bush, K., Young, M., George, L. (2022): Impacts of conservation activities on people who are incarcerated: A case study based on qualitative and quantitative analyses. Ecology and Society, 27(3): 44. DOI:https://doi.org/10.5751/ES-13423270344

Ng, C. S., Duncan, J. R., Koper, N. (2018): Who's "hooting"? Motivations and scientific attitudes of Manitoban citizen science owl surveyors. Avian Conservation and Ecology, 13(2). DOI:https://doi.org/10.5751/ACE01265130209

Peter, M., Diekötter, T., Kremer, K. (2019): Participant Outcomes of Biodiversity Citizen Science Projects: A Systematic Literature Review. Sustainability, 11(10): 2780. DOI:https://doi.org/10.3390/su11102780

Peter, M., Diekötter, T., Höffler, T., Kremer, K. (2021): Biodiversity citizen science: Outcomes for the participating citizens. People and Nature, 3(2): 294–311. DOI:https://doi.org/10.1002/pan3.10193

Peter, M., Diekötter, T., Kremer, K., Höffler, T. (2021): Citizen science project characteristics: Connection to participants' gains in knowledge and skills. PLOS ONE, 16(7): 0253692. DOI:https://doi.org/10.1371/journal.pone.0253692

Phillips, T., Bonney, R., Shirk, J. (2012): What is our impact. Citizen science: Public participation in environmental research. Cornell University Press, Comstock. 304 p.

Phillips, T., Ferguson, M., Minarchek, M., Porticella, N., Bonney, R. (2014): Evaluating learning outcomes from citizen science. Cornell Lab of Ornithology, Ney York. 53 p.

Phillips, T., Porticella, N., Constas, M., Bonney, R. (2018): A Framework for Articulating and Measuring Individual Learning Outcomes from Participation in Citizen Science. Citizen Science: Theory and Practice, 3(2): 3.DOI:https://doi.org/10.5334/cstp.126

Phillips, T. B., Bailey, R. L., Martin, V., Faulkner-Grant, H., Bonter, D. N. (2021): The role of citizen science in management of invasive avian species: What people think, know, and do. Journal of Environmental Management, 280: 111709. DOI:https://doi.org/10.1016/j.jenvman.2020.111709

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

Santori, C., Keith, R. J., Whittington, C. M., Thompson, M. B., Van Dyke, J. U., Spencer, R. (2021): Changes in participant behavior and attitudes are associated with knowledge and skills gained by using a turtle conservation citizen science app. People and Nature, 3(1): 66–76. DOI:https://doi.org/10.1002/pan3.10184

Sakurai, R., Kobori, H., Togane, D., Higgins, L., Young, A., Kishimoto, K., Agnello, G., Cutajar, S., Ham, Y.-S. (2022): A case study from the City Nature Challenge 2018: International comparison

of participants' responses to citizen science in action. Biodiversity, 23(1): 21–29. DOI:https://doi.org/10.1080/14888386.2022.2054860

Shah, H. R., & Martinez, L. R. (2016): Current Approaches in Implementing Citizen Science in the Classroom. Journal of Microbiology & Biology Education, 17(1): 17–22. DOI:https://doi.org/10.1128/jmbe.v17i1.1032

Sharma, N., Greaves, S., Siddharthan, A., Anderson, H., Robinson, A., Colucci Gray, L., Wibowo, A. T., Bostock, H., Salisbury, A., Roberts, S., Slawson, D., Van der Wal, R. (2019): From citizen science to citizen action: Analyzing the potential for a digital platform to cultivate attachments to nature. Journal of Science Communication, 18(01). DOI:https://doi.org/10.22323/2.18010207

Stemler, S. (2001): "An overview of content analysis," Practical Assessment, Research, and Evaluation. 17(17). DOI:https://doi.org/10.7275/z6fm

Sturm, U., Straka, T. M., Moormann, A., Egerer, M. (2021): Fascination and Joy: Emotions Predict Urban Gardeners' Pro-Pollinator Behaviour. Insects, 12(9): 785. DOI:https.org/10.3390/insects12090785

Szép, T. & Gibbons, D. (2000): Monitoring of common breeding birds in Hungary using a randomized sampling design. The Ring, 22: 45–55.

Turrini, T., Dörler, D., Richter, A., Heigl, F., Bonn, A. (2018): The threefold potential of environmental citizen science Generating knowledge, creating learning opportunities and enabling civic participation. Biological Conservation, 225:17186.DOI:https://doi.org/10.1016/j.biocon.2018.03.024

Wehn, U., Gharesifard, M., Ceccaroni, L., Joyce, H., Ajates, R., Woods, S., Bilbao, A., Parkinson, S., Gold, M.,Wheatland, J. (2021): Impact assessment of citizen science: State of the art and guiding principles for a consolidated approach. Sustainability Science, 16(5): 1683–1699. DOI:https://doi.org/10.1007/s11625-021009-2

Weisberg, D. S., Kovaka, K., Vaca, E., Weisberg, M. (2023): LAVA-Lobos: Raising Environmental Awareness through Community Science in the Galápagos Islands. Citizen Science: Theory and Practice, 8(1). DOI:https://doi.org/10.5334/cstp.423

White, M. E., Hamlin, I., Butler, C. W., Richardson, M. (2023): The Joy of Birds: The effect of rating for joy or counting garden bird species on well-being, anxiety, and nature connection. Urban Ecosystems. DOI:https://doi.org/10.1007/s11252-023-01334-y

Young, B. E., Dodge, N., Hunt, P. D., Ormes, M., Schlesinger, M. D., Shaw, H. Y. (2019): Using citizen science data to support conservation in environmental regulatory contexts. Biological Conservation, 237:57-62. DOI:https://doi.org/10.1016/j.biocon.2019.06.016