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Citizen science and civic ecology: merging paths to stewardship

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Abstract
Take Back the Block is a community beautification and citizen science program established for West Baltimore, Maryland (MD) residents. Citizen science, given its focus on data gathering, provides an ideal context to integrate adaptive management while encouraging locally based stewardship through civic ecology practices. The goal of this research is to show how integrating civic ecology practices with adaptive co-management of resources and citizen science can lead to meaningful environmental stewardship. We begin with a structured discussion comparing civic ecology to adaptive management and citizen science. We then share information about our civic ecology-oriented citizen science project that is both consistent with the ten principles of civic ecology practices and strives for adaptive co-management. In many ways, we found that our project aligned well with civic ecology practices with a few changes such as inviting members external to the community to participate and making data collection a component of the stewardship activities. Members of the project were able to achieve some stewardship goals in reclaiming and greening public spaces. In addition, in alignment with adaptive management, they iteratively gathered information that guided projects and serves as evidence and a model of adaptive co-management for communities outside of Baltimore.

Keywords Civic ecology · Citizen science · Collaborative adaptive management

Introduction

Citizen science can serve both as an important data collection tool and as a means to engage the public with science (Bonney et al. 2009a). Environmental citizen science projects are those where members of the public engage with experts in authentic research endeavors (Jordan et al. 2015). Citizen science has expanded the data collection capacity of experts where data needs are beyond which they can collect by themselves, especially where involvement is enjoyable, such as ornithology (Bonney et al. 2009b) and invasive plant detection (Crall et al. 2012; Jordan et al. 2012b). Outcomes from these types of projects can include not only scientific data, but also collaborative learning, and possibly increased community capacity for local stewardship action (e.g., Bonney et al. 2009a, Gray et al. 2012, Jordan et al. 2012a, Gray et al. 2016, Jordan et al. 2016).

There are many types of citizen science defined by the extent to which participants are engaged in the scientific process. In collaborative citizen science models, participants act as partners in addressing research questions versus a more traditional scientist or expert-led type of citizen science project, where scientists or other experts generate research questions or protocols. Herein, the collaborative model includes the following frameworks: (1) collaborative, where research responsibilities are shared between scientists and citizen scientists; (2) co-created, where citizen scientists take the lead on the project and research; and (3) collegial, where scientists play only a minimal role in the research (Bonney et al. 2009a; Shirk et al. 2012). Such collaborative partnerships may prove especially effective toward meeting goals in environmental systems and communities where research is necessary to address both social and ecological problems. Further, when these issues are local, participants can engage in the management decision-making process (Bonney et al. 2009b), possibly through adaptive management.

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Adaptive management involves continuous monitoring of resources in an effort to reduce the uncertainty that can hinder decisions about environmental issues (Holling 1978). The process is necessarily iterative, involves on-going social learning, and can be responsive to change. Individuals work collaboratively, and over time, to refine their ideas based on the data gathered and decisions made. When adaptive co-management (Folke et al. 2003, Armitage et al. 2008, Plummer 2009) occurs, this process is shared among stakeholders (see Defeo et al. 2015 for case examples).

Learning from the information gathered is important to the adaptive co-management process. In adaptive co-management, learning is social (see Buck et al. 2001). In social learning, participants gather information in collaborative contexts in an effort to integrate and foster varied perspectives. Critical to the process are the collaborative interactions, complex system thinking, and critical reflection (Plummer and FitzGibbon 2008). The process of social learning has been described as incorporating three loops: (1) the primary loop is the information gathering phase, (2) the secondary loop features theory building, and (3) the third loop focuses on challenging assumptions and established ideas (Maarleveld and Dabgbégnon 1999; Keen et al. 2005). This iterative process requires ongoing input of information throughout, which by definition characterizes citizen science. Jordan et al. (2016) and Gray et al. (2017) both explored the outcomes of a collaborative citizen science program merged with adaptive co-management and reported success through the measure of participant goals met mostly through stewardship.

Environmental and community stewardship is a major outcome for projects featuring civic ecology practices. Stewardship is defined as those actions that seek to preserve and in some cases improve community and environmental functions. Civic ecology refers to experiences where people in cities and other heavily human-influenced environments are engaged in environmental and community stewardship practices (e.g., Krasny et al. 2014). Programs that have integrated the ten principles of civic ecology (as identified in Table 1), such as Garden Mosaics (Krasny and Tidball 2009) and Rocking the Boat (Kudryavtsev et al. 2012), have been shown to link residents with their local environment in efforts to advance civic engagement and stewardship (see review in Krasny et al. 2014). In addition, these authors report that individuals engaged in civic ecology learn about their local biological/cultural diversity and ecosystem services. In many cases, specific outcomes of civic ecology featured resource management practices have not been well-reported (Susskind et al. 2012).

A major goal of this research was to explore the plausibility and outcomes of a citizen science project integrated with adaptive co-management and civic ecology (Fig. 1). We merged citizen science, civic ecology, and adaptive co-management to maximize benefit to community and environment (Table 2). In merging these concepts, we sought to maximize stewardship outcomes in a manner that is sustained much like what is reported from civic ecology practices, but also engage experts and decision-makers in the broader adaptive management of local resources. Necessary to both, however, is ongoing data and information collection much that that reported in collaborative type citizen science.

In this project, we focus on citizen scientists engaged in civic ecology and adaptive management practices in a West Baltimore neighborhood. Below, we first describe the broader contributory citizen science program that took place and how a subsection of this program evolved into an adoption of civic ecology principles (Krasny and Tidball 2012) in an effort to better address community research and stewardship needs. Volunteers for this project engaged in iterative cycles of information gathering and project planning. Ultimately, we wanted to determine if individuals engaged in ongoing stewardship action.

Take Back the Block and mosquito control The citizen science and civic ecology project described here is part of Take Back the Block (www.baltimoremosquitoes.weebly.com), which is a community beautification and citizen science project for West Baltimore, MD, residents. Take Back the Block (TBB) stemmed from long-term research conducted by research teams in the area who were seeking to understand how structural variation in urban housing decay resulted in changing mosquito populations. The citizen science and beautification portion of TBB involves members of the public in gardening, trash removal, multigenerational discussions (schoolchildren, teachers, parents, and grandparents), learning basic advocacy principles, and data gathering and visualization. The authors received federal funding to design and study TBB. Because we were not members of the community, we asked several community partners such as those involved in nature outreach, youth and civic engagement, and church leaders to identify potential stakeholders for engagement in TBB. Some of these organizations included the No Boundaries Coalition, specific neighborhood associations, a community association around one of our parks of interest, and Parks & People, which is a neighborhood revitalization and greening program.

A major portion of Take Back the Block was a contributory type citizen science project called Mosquito Stoppers (described in Jordan et al. (2017)). The explicit scientific goals of the Mosquito Stoppers project were (1) to determine how different neighborhoods in West Baltimore vary in terms of mosquito abundance and (2) to determine the extent to which the removal of mosquito breeding habitat reduces that abundance. Effective mosquito control requires spatially explicit knowledge about where the mosquitoes breed and where nuisance populations are greatest. In urban settings, these spatial scales can be quite small, with large block-to-block variation in abundance of mosquitoes (Hemme et al. 2010). Given that these data are difficult to collect at the relevant spatial scales, the Mosquito

Table 1 Ten principles of civic ecology (from Krasny and Tidball 2012) and the major themes from our Mosquito Stoppers Civic Ecology Practices (MS CEP) project

Emergence: where and why do civic ecology practices happen?	MS CEP
1. Civic ecology practices emerge in broken places.	West Baltimore, MD; although we do not call this location broken.
2. Because of their love for life and love for the places they have lost, civic ecology stewards defy, reclaim, and re-create these broken places.	Organizing cleanups, working with community and beautification, and advocacy.
Bricolage: piecing the practice together	
3. In re-creating place, civic ecology practices re-create community.	Working with each other; remaining empowered.
4. Civic ecology stewards draw on social-ecological memories to re-create places and communities.	Recalling history of abandonment and transience.
5. Civic ecology practices produce ecosystem services.	Focusing on cultural services.
6. Civic ecology practices foster well-being.	Putting photos of beauty and decay on display.
7. Civic ecology practices provide opportunities for learning.	Discussing with each other and collecting data.
Health	
8. Civic ecology practices start out as local innovations and expand to encompass multiple partnerships.	Moving toward growing partnerships.
9. Civic ecology practices are embedded in cycles of chaos and renewal, which in turn are nested in social-ecological systems.	West Baltimore and its neighborhoods changing with time.
Policy makers: understanding and enabling	
10. Policy makers have a role to play in growing civic ecology practices.	Advocating for and educating neighborhood communities.

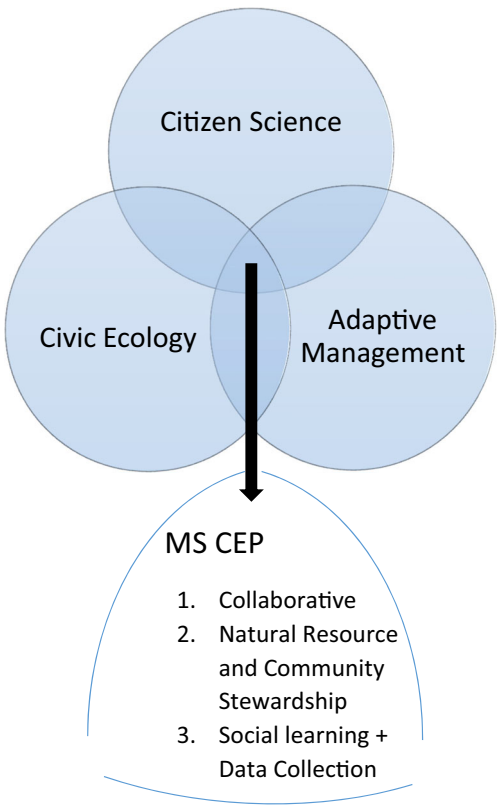

Fig. 1 Conceptual diagram of how the Mosquito Stoppers Civic Ecology Practices (MS CEP) project integrates themes from citizen science, civic ecology, and adaptive management

Stoppers study explored the accuracy and potential spatial extent of citizen-scientist-generated data to meet these needs. We tested the efficacy and accuracy of citizen-scientist-generated data used to assist researchers study the distribution of the Asian tiger mosquito (*Aedes albopictus*). Engaging these residents also served a second goal for the researchers, which was to promote learning and behavioral change to limit *Ae. albopictus* breeding (e.g., trash handling techniques and reducing opportunities for short-term standing water).

A few members of Mosquito Stoppers were interested in becoming engaged beyond the Mosquito Stoppers project. In March 2016, we, therefore, established a group dedicated to civic ecology practice. Members were generally long-term residents from multiple West Baltimore neighborhoods, and they varied in ethnicity and gender. Two members of this group were involved in Mosquito Stoppers, with the other six being subsequently recruited by these members or from other members of Take Back the Block. All eight members of this civic ecology practice-oriented group were given the citizen science protocol and contributed to the Mosquito Stoppers data collection efforts as well. We call this group Mosquito Stoppers Civic Ecology Practice (hereafter MS CEP). The protocol involved minimal training delivered via an information packet and involved participants designating spaces to study, identifying potential larval mosquito habitats in that study area, describing mosquito encounter and nuisance rates, and photographing the extent of the decay in that area over the course of the summer (see Jordan et al. 2017 for overview).

Table 2 Comparison of project elements culminating into Mosquito Stoppers Civic Ecology Practices (MS CEP) project

Elements of the project	Adaptive co-management	Citizen science	Civic ecology practices	Project described in this paper (MS CEP)
Project initiation	Resource manager driven	Often scientist, but also community	Community driven	Community requested, researcher driven
Nature of collaboration	Highly collaborative	Can be highly collaborative	Highly collaborative	Highly collaborative
Focus of the project	Natural resources	Can be natural resources	Natural and social resource driven	Natural and social resource driven
Stewardship as an outcome?	Yes	Can be	Yes	Yes
Project timing	Continuous	Can be continuous	Continuous	Intended to be continuous
Social learning as a part of the project?	Yes	Can be	Yes	Yes
Data collection as part of project?	Yes	Yes	Can be	Yes

Methods

This study employs focus groups and pre- and post-surveys of participants. The civic ecology experience mostly adhered to the ten principles highlighted in Krasny and Tidball (2012) (Table 1, see discussion for departures from these principles). We, therefore, report our results using these ten principles. While civic ecology practices feature major themes present in community-based stewardship projects, these principles do not present a process or procedure to follow. Below, we describe our protocol.

The eight members and the researchers of the MS CEP group met once a month over a 5-month period for about 2 h either on a Saturday afternoon or a weekday evening (for a total of five meetings). Meeting times were spaced to allow group members time to participate in Mosquito Stoppers outreach activities. Of the eight members, two identified as male and the rest as female. All participants were over 30 and two reported being retired. Two of the eight reported higher socio-economic status. This question did not present particular dollar amounts but was structured to allow individual interpretation of the term.

One researcher ensured that all members had the opportunity to speak while the others took notes, which included direct quotes. The first meeting acknowledged that participants wanted to engage in stewardship. We asked "how could collective action help this?" From there, no further structured questions were necessary. Participants guided the discussion about progress and future goals. Researchers only asked for clarification. A single researcher summarized all notes at the end of the session. It was during this time that the group members were able to verify the meaning of their summarized statements or direct quotes. We used only the written notes, and no further data processing occurred. In addition, at the end of the meeting, we stated goals for the next meeting and tasks to meet these goals noted.

Prior to our first meeting and after our last meeting, we asked the members to complete a brief questionnaire regarding experiences with trash and empowerment to remediate trash issues (see supplemental material). We asked all the members of the broader Mosquito Stoppers program to complete this questionnaire, but any data referenced below were taken only from the MS CEP group members. Below, we list the ten major civic ecology principles (Krasny and Tidball 2012) associated with civic ecology practices. We align themes that emerged in the focus group discussions with these practices.

The focus groups comprised of stakeholders who informed our understanding of the following: (1) the establishment of goals, (2) highlighting steps that could be taken to meet the goals, and (3) create a timeline for the group to meet the goals. We decided to use a focus group approach because we wanted to bring the group members together to share and compare their experiences in shared issues of importance. We felt that use of this method was well aligned with the process of civic ecology. Other individualized approaches, while providing more structured tangibles to the project, would not allow the co-creative sentiment of the group effort that we wanted to foster (see Breen 2007 for a discussion). Further, focus group methodologies provide opportunities for shared learning. Because participants were spending time with us, we wanted them to leave the meetings with a sense of value. As meeting ideas continually built on the previous shared discussions, and this research is exploratory, we were not concerned about potential shifting group sizes.

Inherent to the notion of citizen science is the collection of data to inform decisions. As might be expected from a group of citizen scientists who were subsequently seeking to improve stewardship practice, the individuals of the MS CEP group decided to embark on data collection after the third meeting and beyond the Mosquito Stoppers citizen science project. The methods for this data collection process followed a semi-structured interview protocol. During two local community events, we read 46 West Baltimore residents (not associated with the MS CEP or Mosquito Stoppers projects) a brief article on the uneven burden of trash distribution and

collection in New York City. This article highlighted government, social justice, and personal control issues. While the MS CEP group members helped to create the interview, the researchers, because of Institutional Review Board constraints, delivered the interview. We then asked these residents the following question: "Do you think the city would respond differently to others making similar complaints (about trash issues) but in different neighborhoods? Why or why not?" All data were transcribed and two researchers coded all interview data by reading all responses and deductively generating possible codes. From there, all codes were then aggregated into those listed in the Table 3 and re-coded by the two researchers alluded to above. This re-coding resulted in 100% agreement.

Results

Emergence: where and why do civic ecology practices happen?

1. Civic ecology practices emerge in broken places: This project took place in West Baltimore, MD, although we prefer not to call this location broken.

From the first meeting and throughout, members of the MS CEP group expressed concern about the violence, divestment, crime, and failing infrastructure they see in West Baltimore. They also pointed out population loss and a decline in organizations working to address these issues. Ecologists working with the Baltimore Ecosystem Study describe ecosystem degradation and high numbers of invasive species and poor outdoor and indoor water and air quality.

We as researchers chose not to probe too deeply into the broad ways in which the area is failing to meet human and environmental needs, but rather to focus on the residents with whom we worked and their impressions of their place. After a long discussion about the problems their neighborhoods are facing, one resident stated, "Neglect is the new normal," to which the entire group nodded. While this project focused on the trash problem and land stewardship, these discussions clarify the other ways in which human and environmental life are highly stressed and the opportunity to improve the quality of life.

Table 3 Coded data from 46 West Baltimore residents' responses to the following question: "Do you think the city would respond differently to others making similar complaints (about trash issues) but in different neighborhoods? Why or why not?" Of note is that individual action comprised a major portion of the responses, with economic/civic issues taking slightly less than 50% of the responses

Response type	Number of individuals
City doesn't care	3
Money/class	17
No difference	2
No response/do not know	13
People not taking action	11

2. Because of their love for life and love for the places they have lost, civic ecology stewards defy, reclaim, and recreate these broken places: We organized clean ups, community events, beautification projects, and engaged in advocacy.

This practice is perhaps the most important for the members of the MS CEP based on the three major goals highlighted by the group:

A. Directly cleaning up and beautifying the space: members take action

When considering the issue of trash, one individual mentioned, "This person did an illegal act of beautifying but if we make a big deal they will get cited and then what will happen?" Another member of the group mentioned that the risk of taking illegal action was worth it, and this member had taken control of a fountain located in a public park. They were, without city permission, adding a type of biological control that worked to keep the mosquitoes and algae low so that the fountain could continue to be enjoyed. Later in the conversation, another individual described in detail how they "Took a picture...along this stretch and there were cups and cartons everywhere. Along Martin Luther King Boulevard…I usually don't go around praising leaders but this is Dr. King! There are cups and junk all over the drain...when I was at a bus stop [it] had a cell phone! Someone had tossed it in the drain. The drain was clogged and things couldn't get in there. I didn't think people should be treating Martin Luther King's Boulevard like that!" Later during the same discussion, that group took the initiative to plan a cleanup at that location.

B. Working with youth to clean up and beautify the space: establishing a voice

This part of the discussion began with one individual, who stated, "[There is] a charter school. They work so hard with the kids. The trashcans are painted [for example]. If we get them really young…" Another inserted nodding, "We just need to train them young." A third member stated, "As of last two weeks, 50 kids are working on the [unnamed] block on Baltimore for cleaning!" The original speaker enthusiastically replied "Why not take kids from inside? Let them have a voice in what happens. In what they do." With these comments, another member revealed that they also worked with youth at a middle school focusing on trash, environment, and gardening.

C. Advocating for city action: moving beyond perceived and realized bureaucratic obstacles

One member of the group stated when "At some point I decided to make an issue about that pile. Every day I call the city...and they have a system... [I say] a street up, under a tree, and then you will get an email or call: "we see it, but you need to report it with the address." And I was like "I reported it and you know what I meant!" To this, another said, "They come down on the landlords to come down on the tenants." To this, the first individual commented about how reporting to the city resulted in action following with, "I remember when we got nice trash cans and they used to pick up the trash." They all agreed that you "got to keep calling."

Members of the group, while sharing photos of the places where they live (taken as part of the Mosquito Stoppers project), talked about their efforts to re-create their place by eliminating trash and beautifying their spaces. Based on the discussions above, it is evident that there was a desire to reclaim.

Bricolage: piecing the practice together

3. In re-creating place, civic ecology practices re-create community: In working together, we helped support each other.

An Internet search of t Baltimore non-profits yielded over 22 organizations with independent websites that serve West Baltimore and beyond. This search serves as an index of the effort being allocated to building human potential in the face of numerous challenges of an area clearly designated as "broken." The neighborhoods in West Baltimore were experiencing an especially volatile time, and the local community groups were especially active. This was evident by meeting other groups in action (e.g., The No Boundaries Coalition), and through formal association with other groups (e.g., The Neighborhood Associations, a community association around one of our parks of interest, and Parks & People, a neighborhood revitalization and greening program). Actions were also being taken to create an urban renewal organization that at the time of this writing had become formalized.

All eight members completed the questionnaire given pre- and post-participation in MS CEP. Recall that we asked members to provide thoughts regarding the major trash issues and their empowerment and engagement in addressing such issues. Our group of eight was mixed in their feelings. Those who rated their empowerment levels as low tended to lack faith in city officials, their ability to enact change, and the likelihood that the city would respond to complaints through the help call line. These individuals (three out of the eight) reported that they never tried to access the help call line, and two of these were the only ones to not attend all meetings. Both individuals were contacted following our meetings, and one responded that they lacked the time to continue.

Of the five individuals who tended to rate empowerment as high, all shared strong belief in working together and individual action to enact change. Interestingly, the two of these five who also reported a higher socio-economic status also believed in the power of individual action to achieve change. This was in contrast to the other three individuals who reported a lower socio-economic status. These individuals also viewed the collective action taken by the city as seeking to benefit all individuals, whereas the three individuals who reported lower socio-economic status tended to believe the city was making collective decisions that favor wealthier neighborhoods over poorer ones. Certainly, data support the notion that while members of both high and low SES tend to enjoy similar places in these neighborhoods, individuals from lower SES report a greater number of unpleasant and unsafe places (Jordan et al., unpub data).

4. Civic ecology stewards draw on social-ecological memories to re-create places and communities: We recalled personal histories of what used to be and what is now abandoned.

In one of the latter group discussions, the group shared memories of how the spaces once looked. One individual discussed how nice the area was when she bought her home many years earlier, and now she would be lucky to be able to sell it. This was contrasted by another individual who mentioned that he had been living in his home for his entire life. He also recalled an unmanaged and non-designated pile of trash that had been located near his home since he was 6 years old (at time of writing, this individual is 48 years old). A third individual discussed the historical value of some homes near her apartment building, which have been left in neglect.

What is unclear is how far back in time each member of the group's experience with urban decay traces, as none of the group members had positive views of what the neighborhoods were like in the past, regardless of the amount of time that they lived there. Individuals also made statements like "The community sees it as like normal," referring to the trash, "[There are] buildings nearby that have been there for a while… just sitting there!" referring to the abandonment, "Vacancy is part of the culture of Baltimore city," "When you go elsewhere to Savannah or Los Angeles, it didn't look like this. It seems it is our culture...there is only so much that they can fix," and "There is this web image...Baltimore [is the most] beautiful city in the country...and the trash was on the bench!" In spite of these harsh realities, six of the eight individuals continued to work in their individual capacity to enact change.

5. Civic ecology practices produce ecosystem services: We focused on cultural ecosystem services.

The extent to which ecosystems services are produced is unclear, given the short duration of our project. There are certainly actions that should, in theory, produce services. In the short term, the efforts of the group served to make the spaces that they targeted more esthetically pleasing. Doing so provides a cultural ecosystem service (UN Millennium Ecosystem Assessment 2000). Water quality may improve, and the habitats that were cleaned may support greater biodiversity. Important to this project is measurements of these services will continue in the future.

6. Civic ecology practices foster well-being: We focused on beauty and pride in the face of decay.

Much like the statements provided above, it is unclear to what extent well-being is being promoted. One of the actions that we had planned was a social media campaign. Unfortunately, for lack of support by certain individuals outside of our group, this effort failed. Not surprisingly, members were disappointed. When we inspected empowerment variables pre-to-post participation, none of the remaining members experienced a lack of empowerment post-participation. Perhaps, the other actions bolstered individual efficacy. It could also be that these individuals were quite accustomed to successes and failures as evident by their beliefs entering the group.

One of the project successes was photos taken by group members were selected for display during a local (but well attended) art exhibition (project further described in Biehler et al. (2018). While her photos were on display, one individual described how much better she was feeling mentally and physically after being a part of this project. The potential for a project like the one described to foster well-being, at least in the short-term, certainly exists.

7. Civic ecology practices provide opportunities for learning: We learned from each other and engaged in citizen science to learn more collectively.

Learning can be viewed on multiple levels. It can happen on the part of individuals, groups, and even institutions. Certainly, group member engagement with citizen science enabled an opportunity to learn about ecology, urban decay, and urban renewal efforts. While we did not measure these directly with our group, the citizen science project (see Jordan et al. 2017 for results) evaluation indicated that those who participated tended to self-report that they learned something from the project.

What was more meaningful perhaps was the extent to which the citizen science and scientist data sets, which were generated adaptively, resulted in knowledge that could help the group learn and plan subsequent action. Methods for removing mosquito habitat were tested during Mosquito Stoppers project and results shared with the MS CEP group for improved management action. Further, some group members had been involved in other efforts to engage community members of their community and inform city policy.

Table 3 is an example of a data collection learning experience undertaken by the group. The goal for this experience was to understand what community members thought about the city's role in trash inequality within the city. Of the responses given, individual action was cited as a factor in about a third of responses, which is less often than other social issues cumulatively mentioned (Table 3), yet it is a notable proportion. This was heartening to the group who felt that if people placed importance on action, and if action was subsequently facilitated, many would participate. The group then decided to work on a petition to the city that focused on trash removal services.

Health

8. Civic ecology practices start out as local innovations and expand to encompass multiple partnerships: We focused on creating new partnerships and growing old partnerships.

It is unclear as to how currently adopted stewardship practices started (e.g., neighborhood clean ups, etc.). As a group, we discussed innovations such as beautifying trash receptacles, engaging youth in gardening and other beautification practices, continuing to gather ecological data, and advocating to the city as a unified voice through multiple media. These practices exist in small parts in some focal areas of the neighborhoods but are certainly not widespread. One member of our group is a leader in the new community partnership group discussed above, and he mentioned that he will take these ideas and engage the larger partnerships.

9. Civic ecology practices are embedded in cycles of chaos and renewal, which in turn are nested in social-ecological systems: We discussed the socio-political change in West Baltimore and shared real-time examples of decay and renewal.

West Baltimore is certainly a social-ecological system under stress. Freddie Gray's death in West Baltimore incited riots that caused damage to property, although it should be noted that a greater number of residents engaged in property clean-up, which may provide insight into local community resilience (i.e., ability to recover from stress) and urban renewal. Further, group members have indicated increased police and public tensions, and the murder rate in West Baltimore increased during the MS CEP project duration. In some ways, these stressors may seem impervious to renewal: "They don't care about it. They care, but they don't.... It is hard to engage people in research stuff...right now there is this myth...there

is a gang war going on...it makes it hard for me to go to someone and say you want to [join in a project like ours] ...they don't understand that these (the buildings) is about the community health...they can't hear that...the assassins come to kill someone and they kill everyone around...how do they care about [our project] like that..." The prior statement was made by a longtime West Baltimore resident. What is important to note is that in spite of the problems she articulated, this individual continues to volunteer and spends a great deal of time working on projects like the one described here. In many ways, the ongoing stressors and the ways in which individuals cope as described above represent how decay and renewal continue to persist.

Policy makers: understanding and enabling

10. Policy makers have a role to play in growing civic ecology practices: We engaged in advocacy.

A guest community organization expert was invited to one of the MS CEP meetings. During a discussion about how difficult it was to engage friends and neighbors in environmental issues, he stated "…hence, focus on human health and wellness to the community...Lead is a problem...associated with neurobehavioral effects including violence [received loud "yes" from individuals]. Environmental violence and cultural violence.... If community is unhealthy, they are going to act unhealthy...Individuals spoke about the system. The photos are reflecting part of the system...how do we put these photos to work, to fight for change...the vacant lots program is supposed to be doing this. [You've said this is normal] ...why is this normal? Some places have zero waste commissions. It sounds like the city could be doing more." To this, one of the group stated, "It happens with the administration...the previous admin... focused on refurbishing these homes, [after all]." A usually quiet member also revealed that she spoke with a city council member and her request for new trash receptacles was honored. By the end of this particular discussion, the group members acknowledged a role for policy makers.

Furthermore, the group highlighted the potential for direct action with respect to their green spaces. At this point, one of the researchers presented data taken from the contributory citizen science program which showed data on mosquito risk, trash, and feelings about outdoor spaces (Jordan et al. 2017 and Jordan et al. unpub). Given this information, the group discussed how they could advocate for park space beautification at a local level and reduction of building abandonment on a city-wide scale. The latter discussion was the most challenging because most of the group felt that bringing large-scale economic resources to the area would be the only way to deal with safe removal of abandoned buildings. The former seemed a bit more doable for the shorter term.

Civic ecology practices merged with collaborative citizen science and adaptive co-management: outcomes

The final discussion regarding stewardship action, which featured park beautification and therefore greenspace revitalization, went in two directions. First, could the city be encouraged to increase or change trash removal practice? This opened a larger discussion about why certain neighborhoods seemed to get more city attention. During this discussion, some individuals mentioned what others in their neighborhoods might be thinking, but they were not sure. Because members of the group planned on attending a few large neighborhood events, the researchers offered to help gather data that would highlight resident impressions about why individuals perceived greater focus of the city on certain areas. In doing so, the group hoped that members could see the value of information gathering (aka citizen science as conceptualized by our project). The second direction in discussion of park beautification and greenspace revitalization focused on obtaining resources for park place beautification in a manner that would attract visitors, but not pests such as mosquitoes. Regarding this, there was a sense of pessimism that this space would be kept pleasant. Again, the discussion of a data-gathering endeavor arose. It was posed that a demonstration project could be completed through which an area would be beautified and trash cans painted. It would then be monitored and used as a test for the city to demonstrate that with sufficient civic oversight, they could maintain places that have traditionally been degraded. The group also decided to pursue this project. The pilot of this stewardship project was implemented in summer 2017 in cooperation with the larger community group, and data collection protocols are being generated and management targets are being identified. In this manner, individuals can track the ecological and social progress around a particular space.

Discussion

Outcomes of this project suggest that there is value in integrating ideas about citizen science and adaptive co-management into a project featuring civic ecology practices. We argue that incorporating adaptive management and citizen science into civic ecology can enable environmental stewards to measure their progress toward their goals. Additionally, because of the potential for formal science partnerships, we can track the results of the collaborative adaptive management-citizen science process and share with decision-makers outside of the community.

A limitation of this work was small sample size and variable attendance. This resulted in difficulty with sustaining individual engagement, with variable attendance being an especially

difficult problem, which can result in disengagement (Poulin et al. 2005). It is important to acknowledge, though, that individual personality is an essential predictor of persistence in change agency (Morris and Staggenborg 2004). The group describe here was not different, as we discussed members' past affiliations, optimism, and inclinations to push for change.

The MS CEP project also departed from ten principles highlighted in Krasny and Tidball (2012). The three main areas of deviation were (1) incorporating researchers from the outside, (2) short-term time scale, and (3) data collection. First, civic ecology is driven from within the community (Krasny and Tidball 2012), and researchers tend to come from outside of the community of participants. In this study, however, researchers were also group members and participated in all aspects of the MS CEP portion of the project. The questions discussed among the researchers were whether the researchers benefited the group's activities, and if so, could this could be part of a sustainable model. We likened our participation to that of an advisor brought into the group's activity. Precedence for this is found within examples of citizen and community science, where scientists are engaged as consultants (Shirk et al. 2012).

Next, civic ecology practices are sustained (Krasny and Tidball 2012). The MS CEP dissolved after 9 months. What is important to note is most group members, including the researchers, joined the larger community group working in the area. This seemed prudent given the advocacy goals of the civic ecology group and the scales of the problems that the community faces (e.g., building abandonment). It will be interesting to follow how the larger group balances localized needs to that of the cross-neighborhood partnership. We were unable to find discussions in the literature of how groups engaged in civic ecology practice grow and change over longer time scales.

Finally, a major departure from what researchers typically describe in civic ecology practice is the data collection alongside stewardship, which is present within citizen science and adaptive management. While data collection could easily be a part of civic ecology, it currently is not as a major practice (Jordan 2018). Participants in MS CEP participated in two types of citizen science projects. The first was the contributory type project, which served as the starting point for our group. The second type of project was the more collaborative (see Shirk et al. 2012 for a further description of these contrasting citizen science models) pilot of resident experiences (i.e., citizen social science). From the latter, there was the subsequent development of the demonstration project where community members would collect data via an adaptive management model akin to the citizen science described in Jordan et al. (2016).

Beyond the ten principles: a call for integration

In this project, we built on the civic ecology practices previously described, but we have integrated citizen science and adaptive management. The ongoing citizen science project presented an ideal scenario for constant information gathering and subsequent iterations of project design, which represents the primary loop in social learning. From there, the MS CEP group discussed what they were learning across several constructs (e.g., mosquito data, data from participants, and data from the broader local community) and worked to suggest subsequent management action based on these data. In many ways, the latter could serve as an opening to the second loop (e.g., Pahl-Wostl 2006 and see commentary in Reed et al. 2010). As the project continues, it would be interesting to follow the learning progression.

Perhaps, more important to civic ecology practice are the direct stewardship actions (Krasny et al. 2015a, 2015b) that either directly or through policy affect resource management. We suggest that the adaptive learning and decision-making discussions of MS CEP not only can inform current resource management, but may also increase capacity to continue the resource monitoring process and subsequent stewardship. In this manner, the local community is essential to civic ecology practice because project members identify and drive action. There are examples of civic participation in stewardship that have resulted in long-term change (e.g., Locke et al. 2014). Organizations associated with successful stewardship action in New York City for example tended to be older and more established, as opposed to more grassroots and unestablished efforts like the MS CEP (Fisher et al. 2012).

Beyond the field of civic ecology, citizen science in the field of environmental health particularly on environmental justice issues has shown the positive impacts of community-based or collaborative research processes in studying and addressing local environmental issues. For instance, researchers have used the community-based participatory research (CBPR) approach to engage communities concerned about local public health issues in all stages of the research—from development and prioritization of research questions to interpretation and dissemination of study results, to translation of the results to action (Israel et al. 1998 and Minkler 2005). CBPR combined with citizen science in efforts to address the impacts of environmental hazards on health including air quality-related issues (Commodore et al. 2017; Minkler et al. 2012) presents a set of lessons learned and best practices that can be adapted for citizen science stewardship efforts in civic ecology.

Results of community-driven environmental monitoring have included citizen scientists performing filter-based monitoring of particulate matter and collecting soil samples to assess contamination due to heavy metals has led to the closure of the local incinerator, changes in zoning, and more access to green space for local residents (Wilson et al. 2014, 2011; see Commodore et al. 2017 for more examples). In all of these cases, evidence collected through the CBPR framework with citizen science was used to inform local environmental decision-making including increasing the participation of impacted residents in the decision-

making process. Indeed, it is through the implementation of iterative cycles of information gathering and data collection that the reduction of uncertainty can help the community make evidence-based decisions (see for example, Jordan et al. 2016 in the context of collaborative conservation). If one were to visit these neighborhoods in the summer of 2017, when data collection was ongoing and where decisions were being made to increase both the esthetics and ecosystem function of greenspaces (e.g., the permeable pavement project, additional community gardens, and greenspace cleanup and maintenance), one would see evidence for effective development of collaborative-adaptive management through civic ecology stewardship, plus social learning. Social learning is a prominent result in some water management type citizen science projects, with a lesser reported result of changes in decision-making with respect to resource management (Stepenuck and Green 2015).

While there are other examples of citizen science projects resulting in stewardship and community action (e.g., Wilderman et al. 2004), there is little evidence to suggest that adaptive management drove this action. Further, while community learning centered on nature and natural change may improve a sense of well-being (Smith et al. 2015), it is unclear as to whether this learning resulted in persistent social or ecological change. Finally, some have suggested that outcome data in terms of stewardship and other practices in civic ecology are lacking (Silva and Krasny 2014), and therefore, if the integration of civic ecology, citizen science, and adaptive management were adopted, further data supporting the efficacy of this approach is warranted. The latter requires a changing culture of both resource managers, ecologists, and community members with specific attention to establishing system resilience as suggested by Brown and Williams (2015).

In summary, citizen science, given its focus on data gathering, may pose an ideal context to integrate social learning and adaptive management, while encouraging locally based stewardship (i.e., civic ecology practices). When the data gathered and relevant additional information are integrated and used to take action for community improvement or for advocacy, then citizen science serves as a conduit for adaptive co-management and decision-making. The subsequent action that emerges is stewardship, and in keeping with adaptive management, data surrounding stewardship must also be gathered, which can serve as evidence of change.

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