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Toward an Understanding of Citywide Urban Environmental Governance: An Examination of Stewardship Networks in Baltimore and Seattle

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Abstract Efforts to create more sustainable cities are evident in the proliferation of sustainability policies in cities worldwide. It has become widely proposed that the success of these urban sustainability initiatives will require city agencies to partner with, and even cede authority to, organizations from other sectors and levels of government. Yet the resulting collaborative networks are often poorly understood, and the study of large whole networks has been a challenge for researchers. We believe that a better understanding of citywide environmental governance networks can inform evaluations of their effectiveness, thus contributing to improved environmental management. Through two citywide surveys in Baltimore and Seattle, we collected data on the attributes of environmental stewardship organizations and their network relationships. We applied missing data treatment approaches and conducted social network and comparative analyses to examine (a) the organizational composition of the network, and (b) how information and knowledge are shared throughout the network. Findings revealed similarities in the number of actors and their distribution across sectors, but considerable variation in the types and locations of environmental stewardship activities, and in the number and distribution of network ties in the networks of each city. We discuss the results and potential implications of network research for urban sustainability governance.

Keywords Urban sustainability · Governance networks · Social network analysis · Urban natural resources management

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Introduction

Cities are now the dominant form of human settlement. As urbanization continues, cities must respond and adapt to resulting ecological and social changes; they must anticipate future changes while facing existing challenges. This will require a shift in approach. While twentieth century "sanitary cities" organized around separate engineering and managerial tactics to overcome unhealthy conditions for people (Melosi 2000; Johnson 2006; Grove 2009), the goals of the twenty-first century "sustainable city" are more likely to include how to make cities more self-regulating, self-sufficient, and adaptive (Pickett et al. 2011). The urban landscape is fragmented into many parcels under different types of use and ownership, producing a large, diverse group of stakeholders with an interest in resource management decisions (Svendsen and Campbell 2008). This may require a collaborative approach, in which many stakeholder groups share the power and responsibility of managing natural resources (Ostrom 1990; Wondolleck and Yaffee 2000; Koontz et al. 2004).

Together, the organizations participating in these collaborative processes comprise a governing structure known as a "governance network." The methods from several areas of study can be applied to examine governance networks. Most applicable to this study is research that applies social network analysis to understand collaboration in ecological systems (Crona and Bodin 2006; Ernstson et al. 2008; Lauber et al. 2008; Muñoz-Erickson et al. 2010). Despite the rise of network studies, few examine networks in urban social-ecological systems (Ernstson et al. 2010), particularly at the citywide scale. Additionally, scholars have emphasized that network analytical approaches often focus only on the relational ties between actors rather than the characteristics of the network as a whole (Provan et al. 2007; Provan and Kenis 2008). In trying to understand governance networks, they must be considered a structure worthy of study in their own right (O'Toole 1997; Koliba 2006). Although examples of whole network analysis exist (e.g., Kapucu's 2012 study on emergency management networks), studies of large networks at the whole network level present methodological challenges and can be quite time-consuming to execute. Yet these types of large-scale studies provide foundational characterizations that can ground future analyses, offer the context for comparative and longitudinal studies that can reveal patterns across networks and over time, and have the ability to inform practice.

This paper seeks to address the dearth of large whole network studies in general, and in urban social-ecological systems in particular, by examining citywide environmental stewardship networks in Baltimore, MD and Seattle, WA. For each city, the types of organizations and network structure will be characterized both within and across cities. The applied nature of this research and implications of the results for management and future research will be described and discussed.

Policy and Management Context

The cities chosen for this study were Baltimore, MD and Seattle, WA (Table 1). The driving motivation for the selection was interest from several agencies to begin to explore and characterize natural resource governance in the Chesapeake Bay and the Puget Sound—two heavily impacted, urbanized estuarine systems. The USDA Forest Service has several ongoing urban natural resource stewardship projects across the country, and Baltimore and Seattle are two of the cities included in that work. This offered a strong research base and management motivation to pursue these two study areas. Similarities for comparison in the two cities included strong public–private watershed based partnerships such as the Chesapeake Bay Program (www.chesapeakebay.net) and the Puget Sound Partnership (www.psp.wa.gov). Both watersheds are listed with the US EPA's National Estuary Program, which provides funding and technical guidance for management, and encourages and supports collaborative networks. Baltimore and Seattle also have nearly identical population and land areas. They have similar rates of tree canopy cover, and each has programs to increase tree cover.

Yet the histories and socioeconomics are quite different, and we assumed we would find substantial dissimilarity in both the overall number and organizational missions of stewardship organizations found in each city. Baltimore is a historically older, majority black, less wealthy, less educated city with a declining population. In contrast, Seattle is a newer, majority white, wealthier, highly educated city with a rising population (Table 1). While there are some findings to the contrary (c.f. Whittaker et al. 2005), environmentalism has long had a reputation of being an elite, white activity. Specifically related to environmental stewardship behavior, Fisher et al. (2010) reported that volunteers who planted trees in New York City Parks tended to be white, educated, and politically liberal. We also were informed by concurrent research that found views of stewardship by Seattle practitioners tended to focus more on values of ideal nature and pristine wilderness (Romolini 2013). Baltimore practitioners tended to express stewardship more in Christian terms, emphasizing moral obligation and social justice.

Both cities have sustainability initiatives, although Seattle is ahead of Baltimore in developing, supporting, and funding these types of programs. This may be attributed to differing economic conditions (Table 1). Poverty is a top issue in Baltimore, which may contribute to greater concern for meeting basic needs than environmental issues. In Seattle, high tax revenue likely allows for increased funding of environmental programs. At the time of data collection, Seattle ranked third among US cities in park spending per resident; Baltimore ranked at 72nd (Trust for Public Land 2011). Seattle was also among the top ten cities in the country for LEED certified buildings (US Green Building Council 2012). Seattle was a leader in sustainability, with the 20-year "Seattle Comprehensive Plan: Toward a Sustainable Seattle" covering 1994–2014 (Seattle Department of Planning and Development 2005). Baltimore also has a sustainability plan, published in 2009 (Baltimore Commission on Sustainability 2009). Notably, the plan emphasizes the reliance on partnerships with the private and non-profit sector to achieve its goals. It does not indicate how these partnerships are to be formed, maintained, or evaluated.

Another relevant public policy development is the Urban Waters Federal Partnership program. This program united thirteen federal agencies with the goal of improving

Table 1 A comparison of Baltimore and Seattle social and physical characteristics (*Sources* [a]2010 US Census; [b]2000 US Census; [c]Land use/land cover, Seattle, WA 2009; [d]Land Cover, Baltimore, MD 2007)

Attribute	Seattle	Baltimore
Year founded (by European settlers)	1853	1729
Population[a]	608,660	620,961
Population change, 2000–2010[a,b]	45,286 (+)	30,193 (−)
Median household income (dollars)[a]	60,212	38,346
% White[a]	69.5	29.6
% Pop. with Bachelor's degree or higher[a]	56.0	24.2
Land area (sq mi)^2	83.0	80.8
% Tree canopy cover[c,d]	28.1	27.4
Impacted water body	Puget Sound	Chesapeake Bay

coordination among federal agencies and collaboration with local community-led revitalization efforts on urban waterways (Urban Waters Federal Partnership 2013). The Partnership was launched in 2011 with local partnerships at seven pilot locations across the nation, including Baltimore's Patapsco River. This program does not provide new funding; rather it relies on leveraging existing resources and strengthening coordination and collaboration among federal, state, and local partners to meet regulatory requirements. It is particularly related to this study, as data in Baltimore were collected around the same time as the Partnership was formed. Authors of this paper have presented preliminary results at several Partnership meetings, in which participants discussed how to best use the data to actively self-manage the network. Additional Partnership locations added in 2013 included the Green-Duwamish watershed in Seattle, which makes integration of these data possible in that effort as well.

Background and Research Framework

The study of natural resource governance networks spans different bodies of literature. As this area of study rapidly grows, researchers from multiple disciplines utilize varying terminology with often overlapping meaning. Along with other scholars in the field (Provan et al. 2007), we acknowledge the need for a classification system. In the absence of one unifying theory, we briefly review several areas in the literature that grounded the development of this study.

In the United States, approaches to governance of natural resources have changed considerably. Public leaders in the mid-1900s addressed environmental and public health concerns stemming from the Industrial Revolution. The need for strong regulation resulted in the first generation of environmental governance, characterized by centralized, command and control regulation of single media (e.g., air, water, and land) through legislation like the 1970 Clear Air and 1972 Clean Water Acts (Durant et al. 2004), and the creation of the US Environmental Protection Agency. Then, toward the end of the last century, decentralized, bottom-up management began to reshape the traditional emphasis on centralized, top-down government management practices. Bottom-up strategies, such as grassroots ecosystem management (Weber 2000) and civic environmentalism (John 1994), were successful in engaging diverse groups of stakeholders outside of government, addressing geographically and scale appropriate issues, and often providing incentives for compliance rather than punishment for noncompliance. However, bottom-up strategies alone were insufficient. The concerns of early twenty-first century environmental governance are to address complex and rapidly changing social-ecological issues, which may be best achieved through a hybrid, polycentric approach to governance (McGinnis 1999; Ostrom 2005; Kofinas 2009) with a network of interacting institutions having overlapping and varying objectives, authorities, and strengths of linkages (Ostrom 1990). In such networks, the non-profit sector has an increased role in delivering and managing social services (Koliba et al. 2010). The diversity of interests and perspectives represented in these governance networks may offer greater ability to support sustainability goals such as those described above.

Empirical studies of networks have proliferated in the past few decades (Borgatti and Foster 2003; Bergenholtz and Waldstrom 2011). Recent research applies social network analysis to understand interactions among those working in social-ecological systems (Crona and Bodin 2006; Ernstson et al. 2008; Lauber et al. 2008; Muñoz-Erickson et al. 2010). Relevant examples include using network analysis to categorize and assess relationships in natural resource management (Prell et al. 2009), to evaluate social capital in collaborative planning (Mandarano 2009), and to examine structure (Schneider et al. 2003) and effectiveness (Laven et al. 2010) of networks facilitated by federal programs. Yet few studies have focused on the natural resource governance networks in urban areas. Some recent exceptions include examinations of governance

networks and ecosystem services in Stockholm (Ernstson et al. 2008, 2010) and the US urban stewardship network research of which this study is part. We built upon and shared methods with similar co-occurring research efforts in New York, NY and Chicago, IL (c.f. Fisher et al. 2012; Connolly et al. 2013; Belaire et al. 2011) as part of the USDA Forest Service's multi-city stewardship research effort. Environmental stewardship groups were chosen for study because they interact with both natural resources and the social system (Svendsen 2010). A stewardship organization is any group from the non-profit, public, or private sector working to conserve, manage, monitor, advocate for, and educate the public about their local environment (Fisher et al. 2012; Svendsen and Campbell 2008). Stewardship activities may contribute to myriad benefits that have been identified across the literatures (c.f. Romolini et al. 2012). These effects can directly contribute to the achievement of sustainability goals.

This emergent body of urban stewardship research has produced early results in the cities of study. In New York City, researchers have characterized the organizational structure of environmental stewardship (Fisher et al. 2012) and the roles that "bridging" organizations play in managing natural resources (Connolly et al. 2013). In Chicago, researchers found that geographic proximity of office location and field sites increased interactions among stewardship organizations (Belaire et al. 2011). In Seattle, pilot efforts resulted in an organizational census of stewardship organizations in the Puget Sound Region (Wolf et al. 2013) and the development of a practitioner-derived conceptual framework of urban environmental stewardship (Romolini et al. 2012). In Baltimore and Seattle, researchers compared the relationships between tree canopy and the presence of stewardship organizations and the number of ties between them (Romolini et al. 2013a).

However, researchers in this and other projects have struggled with how to do a whole network analysis of populations of hundreds to thousands of organizations, despite the call by scholars that analyses should focus on whole networks (Provan and Kenis 2008). Indeed, a review of inter-organizational network studies from 1985 to 2005 found only 26 whole network empirical studies (Provan et al. 2007). In trying to understand the governance network, it must be considered a social structure worthy of study (O'Toole 1997), which may require the application of new methodological techniques such as data imputation.

Social scientific survey research is often challenged by missing data and particularly with non-response in social surveys. The analysis and mapping of social network structure is even more sensitive to missing data (Burt 1987; Ghani et al. 1998; Borgatti and Molina 2003; Kossinetts 2006). This challenge may contribute to the scarcity of whole network analyses in the literature. Huisman (2009) found that a combination of missing data treatment approaches can help correct for missing data in certain network analyses. One way to address the issue of missing data from non-response is by imputing values through *reconstruction*. Imputation procedures have been used in social science survey research to replace the missing values of a non-respondent with the values of a donor actor from the same dataset (see Andridge and Little 2010 for a review) and can be applied in social network studies to populate the ties of non-responding actors (Burt 1987; Goldstein 1999).

To characterize the structure of the populated networks of study, we examined several concepts—density, centralization, and degree and betweenness centrality—that measure levels of cohesiveness at the network and actor levels. Researchers working on applications of social network analysis and natural resource governance (e.g., Prell et al. 2009; Bodin and Crona 2009; Bodin and Prell 2011) have found these concepts to be particularly relevant to natural resources management.

First, *density* measures how many ties exist divided by the number of available ties. Previous research demonstrates variation in network size affects network cohesion (Friedkin 1991; Moody and White 2003); that is, a smaller network needs a higher level of density than a large one to reflect the same level of cohesion (Friedkin 1981). As reviewed by Bodin and Crona (2009), the natural resource governance literature generally describes a positive relationship between density and joint action. It has also been demonstrated that density may enhance development of knowledge and understanding through exposure to new ideas and an increased amount of information (Bodin and Crona 2009). For example, studies on agriculture and agroforestry demonstrated that information on new technologies and sustainable management practices flowed through informal social ties as opposed to formal institutional structures (e.g., Isaac et al. 2007; Conley and Udry 2001); both from internal and external relationships (Isaac et al. 2007). Furthermore, Sandström (2008) showed that the presence of a positive relationship between density and knowledge development may require fewer ties than needed to enable collective action, defined as, "actions taken by members of a group to further their common interests" (Bogdanor 1987, pp. 113). Indeed, some studies suggest that there might be a tipping point in the relationship; very dense networks may be limited in their ability to receive new information and knowledge, which reduces adaptive capacity (Bodin and Norberg 2005; Little and McDonald 2007; Ruef 2002).

Next, centrality measures characteristics of individual actors within the network (Burt 1992). *Degree centrality* describes to how many others an actor is connected, with *indegree* describing the number of incoming ties and

outdegree describing the number of outgoing ties. In this study, indegree measures from how many organizations an actor receives information, and outdegree measures to how many organizations an actor provides information related to environmental stewardship. The number of ties an actor possesses has been shown to have a positive effect on that actor's influence (Degenne and Forsé 1999). Actors with many ties are the "hubs" of a more centralized network. These actors can effectively distribute information to the rest of the network; however, their ties are often weak and may not have as much influence over other members of the network (Prell et al. 2009). Degree centrality can be seen as a "measure for an actor's *involvement* or *activity* in the network. It does not consider whether an actor is seen as influential or popular." (Prell 2012, pp. 97).

Betweenness centrality describes how many times an actor lies between two others that are themselves disconnected (Freeman 1979). An actor with high betweenness centrality has the potential to be the bridging tie between these other actors, giving the bridging actor the ability to influence the flow of resources (Burt 2004; Granovetter 1973). If this actor is removed, the network will fragment. Actors with high betweenness can diffuse information quickly, and to the less connected parts of the network. "In communication networks, betweenness centrality measures how much potential control an actor has over the flow of information. If an actor rests between many other actors in the network, then this actor can greatly *influence* the network" (Prell 2012, pp. 104, emphasis added). However, their position in between other actors can constrain these organizations to act on one decision (Prell et al. 2009).

Centralization describes the distribution of ties. High centralization is when a small number of organizations hold most of the ties in the network. These actors can effectively diffuse information through the network (Prell et al. 2009). Sandström (2008) found a positive correlation between high network centralization with collective action in natural resource governance networks. However, others argue that the uneven distribution of ties results in asymmetric relations of influence and power (Ernstson et al. 2008; Diani 2003), which can leave out the less connected actors. Bodin and Crona suggest "highly centralized networks may not be appropriate for governing social–ecological systems over time since they are less suited for solving complex tasks. They are also more vulnerable to the removal or dysfunctionality of the few central actors" (pp. 371, 2009).

Provan and Milward point out that there are few studies examining "the relationship between inter-organizational network structures and activities and measures of effectiveness" (2001, pp. 414). This paper aims to characterize the structures of the stewardship networks in the two study cities. We believe that this initial characterization and comparison of network structure is essential to future investigations assessing outcomes and thus the effectiveness of these governance networks.

Methods

This study employed a mixed methods approach. First, ten key informant interviews, compilation of directories of informant organizations, and expanded sampling were conducted to identify the stewardship organizations in each city. Following previous work in New York City (Fisher et al. 2012; Svendsen and Campbell 2008), a stewardship organization was defined broadly as a community group, non-profit, public, or private organization whose work contributed to "conserving, managing, caring for, monitoring, advocating for, or educating about local environments." Organizations were then sent a web-based survey. The survey was based on the New York City Stewardship Mapping Project survey (Fisher et al. 2012), with some modifications in content, and was approved by the Institutional Review Boards at the University of Vermont and the University of Washington. Baltimore and Seattle questions were identical, with the exception of geographically appropriate cues. Survey questions asked about organizational activities, attributes, and relationships with other organizations. The network-related questions asked respondents to list up to ten organizations:

1. from whom they have received information, advice, or expertise related to environmental stewardship in the past year; and
2. to whom they have provided information, advice, or expertise related to environmental stewardship in the past year.

Two funding-related questions were asked in the same way. In total, a responding organization could list up to 40 organizations. This provided the opportunity to use reconstruction to populate the network. Reconstruction involves replacing a missing tie using the value reported by the responding actor in the dyad (Stork and Richards 1992); that is, if Respondent A reports providing information (outgoing tie) to Non-Respondent B, then B is populated with an incoming tie from A. Ties were imputed from the responses to all four questions, thus any two organizations could have up to four ties in the whole network, but the structural analyses were performed on the information ties only. Since the network questions were open-ended, a non-responding organization could be from the original surveyed population or a "unique" organization not previously identified. To be included, a unique organization was (1) identified by a respondent or respondents in at least one of the network questions and (2)

verified to be conducting work within the city boundaries of Baltimore or Seattle. These unique organizations were added to the original population to create an enhanced total population. This process provided a more complete view of the stewardship population in each city. For the analyses described in this paper, the whole network is defined as a subset of the enhanced population consisting of the respondents plus those nominated (Fig. 1).

While reconstructing and imputing data can help address the challenges of non-response in network analyses, there are known limitations to this approach. For example, in his simulation study, Huisman (2009) identifies that biases may remain when using reconstruction and imputation methods in sparsely populated networks, and in networks with more than 40 % missing data, as is the case in this paper. In particular, there is an expected bias toward overrepresentation of the responding actors. Indeed, *t* test results showed a significantly greater mean number of ties held by responding versus non-responding organizations; with responding organizations, holding about twice the mean information ties in Baltimore and about four times the mean info ties as non-respondents in Seattle. It is acknowledged that these approaches have yet to be studied in great detail, and that they will not be able to recover all of the missing ties in the network. However, after considering potential methods, this combination of missing data treatments was determined to be a preferred approach to ignoring the missing data altogether, giving the best possible representation of network structure.

Statistical, network, and comparative analyses were then employed to describe and compare the stewardship networks in each city. Summary statistics were computed to describe the population of organizations and the attributes of the respondents. The social network analysis software UCINET (Borgatti et al. 2002) was used to calculate measures of structure including density, betweenness and degree centrality, and centralization for the information sharing network constructed in each city. The UCINET User's Guide (Borgatti et al. 2002) is available online and provides detailed descriptions of the calculations, which we will briefly describe here. Density is a whole network measure calculated by dividing the total number of actual ties by the total number of possible ties. Centrality measures network cohesion at the actor level. Degree centrality is calculated by summing all of an actor's incoming (in-degree) and outgoing (outdegree) ties. In this study, we focus on outdegree ties, as this measures the number of organizations that are receiving information from a given actor. Betweenness centrality calculates the extent to which an actor falls on the paths between other pairs of actors in the network that are disconnected. For example, if Organization A provides information to Organization B, and Organization B provides information to Organization C but C has no relationship with A, then the path from A to C must be through B. Centralization is a whole network measure that calculates the degree of inequality or variance of centrality in the network. An unequal network is one where one or a few actors hold most of the ties; the classic example is a star-shaped network in which Organization A is central and has outgoing ties to Organizations B, C, D, E, and F, but B–F are only connected by their incoming ties from A and have zero outgoing ties. Centralization is calculated as a percentage; it is the sum of the differences in centrality of the actors in the network divided by what the sum would be in the most centralized, "star" version of the network.

Results and Discussion

The findings for each city are described, discussed, and compared in two sections: (1) "Organizational Composition" section provides the organization-level findings in terms of population and respondent attributes, and (2) "Network Characteristics" section provides the network structural measures.

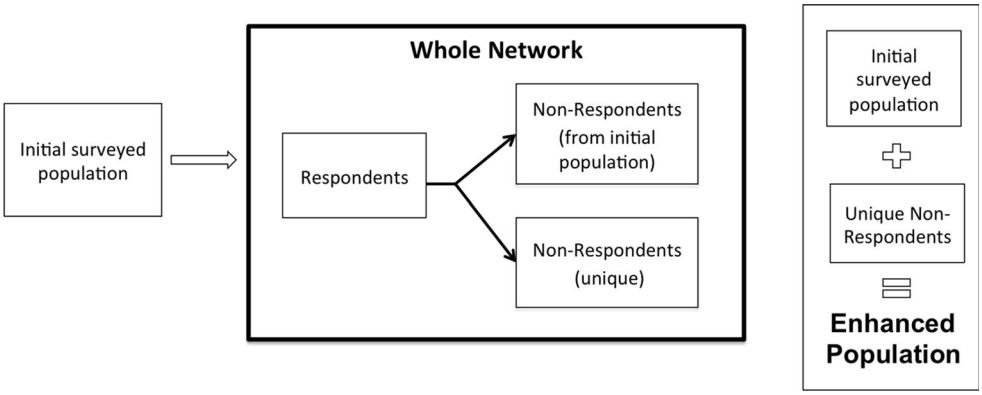

Fig. 1 Data reconstruction produced a more complete picture of the whole network of stewardship organizations in Baltimore and Seattle. The whole network in each city comprises a subset of the enhanced organizational population

Organizational Composition

Population of Organizations

Table 2 summarizes the population data. Expanded sampling techniques were used to first identify 607 organizations in Baltimore and 568 organizations in Seattle that conduct environmental stewardship activities. Response rates were similar across cities: 27.2 % in Baltimore (165 responses) and 25.4 % in Seattle (144 responses). Following Fig. 1, these respondents nominated additional non-responding organizations. In Baltimore, 225 non-respondents were identified, including 96 from the surveyed population and 129 organizations unique to the population. In Seattle, 251 non-respondents were identified, including 95 from the surveyed population and 156 unique organizations. The unique organizations were added to the initial population count, producing an enhanced population of 736 organizations in Baltimore and 724 organizations in Seattle conducting environmental stewardship activities. After reconstructing the data for the non-respondents, 390 (53.0 %) of the enhanced population composed the whole network in Baltimore, and 395 (54.6 %) of the enhanced population composed the whole network in Seattle.

Thus, these networks—390 and 395 organizations—compose the whole stewardship networks in Baltimore and Seattle as described in the remainder of the paper. The whole networks were constructed inductively to include survey respondents and the organizations they nominated as sharing stewardship-related information or funding. Nominees could be surveyed non-respondents or unique organizations. While these networks represent a majority of the stewardship organizations, it is important to note that a large percentage of the enhanced population, 47.0 % in Baltimore and 45.4 % in Seattle, were not identified by others as participating in the network.

We initially expected that we would find a larger overall number of environmental stewardship organizations in Seattle, given indicators such as that city's overall leadership in advancing sustainability and park spending, as well as the Romolini (2013) finding that Seattle practitioners emphasized the importance of ideal nature and pristine wilderness. We did not find that to be the case. Indeed, though nearly identical numbers of stewardship organizations were found in each city, Baltimore had a slightly higher enhanced population with 12 more organizations. This suggests that, though the values that drive action may vary, issues related to environmental stewardship are considered pressing across the two cities, regardless of socioeconomic conditions.

Table 2 Organizational population results from study of stewardship in Baltimore and Seattle

Variable	Baltimore	Seattle
Surveyed population	607	568
Respondents	165	144
Non-respondents	225	251
Whole network participants	390	395
Enhanced population	736	724

Respondent Attributes

As a result of the network data reconstruction, attribute data exist for the survey respondents, but not the whole network. Thus, the data that follow display the characteristics of the responding stewardship organizations in each city, representing attributes of 165 (42.3 %) of the 390 stewardship organizations in Baltimore's whole network, and 144 (36.5 %) of the 395 stewardship organizations in Seattle's whole network.

Among the responding organizations, there was a similar distribution across sectors. Table 3 shows the distribution of organizations across sector types, with a more detailed distribution of organization types within each sector. As illustrated, there are only small differences in organizational distribution across sectors in each city. The non-profit sector dominated each stewardship network, followed by the public sector, and a small representation from the private sector. The large majority of non-profit organizations conducting stewardship activities in each city supports our expectations and the idea that non-profit actors are increasingly more heavily involved in service

Table 3 Distribution by sector of stewardship organizations in Baltimore and Seattle

Legal designation	Baltimore (%)	Seattle (%)
Non-profit sector	78.5	75.0
501(c)(3)	49.1	52.8
501(c)(4)	3.1	1.4
Community group w/o exempt status	26.4	20.8
Public sector	18.4	20.8
Federal agency	2.5	2.8
State agency	1.2	4.2
Local agency	4.3	6.9
Public institution (not an agency)	1.8	2.8
Quasi-governmental	2.5	2.1
School district	6.1	2.1
Private sector	1.2	3.5
Other	1.8	0.7

and delivery of public goods (Koliba 2006). There was some variation between cities, with Baltimore having 3.5 % greater non-profit presence and Seattle having 2.4 % more public and 2.3 % more private representation in stewardship activities. The slightly higher involvement from the private sector in Seattle may reflect the Preservationist values mentioned above infiltrating into business.

The distribution within sectors shows greater differences between the cities. In Baltimore, there are nearly 6 % more community groups without 501(c)(3) or (4) status, though this proportion in each city was higher or equal to the proportion of public sector organizations. This high representation—26 % in Baltimore and 21 % in Seattle—of organizations without any legal designation suggests strong participation of community groups in stewardship activities. There is similar federal agency presence, but Seattle's stewardship network has 2 % more representation of both state and local agencies. This is matched in Baltimore by 4 % higher proportion of school district participation; with a full one-third of Baltimore's public sector respondents coming from the school district. This could be a result of recent efforts to involve schools in sustainability through Baltimore City Public Schools' activities such as the establishment of the Green Schools Network and the 33-acre Great Kids Farm, though this may merit further interview research.

As we assumed, organizations across cities displayed clear relative differences in their stated functions and purposes. Organizations were asked to choose their main organizational purpose or function from a list of 19 possible responses. "Environment" was the dominant functional domain for organizations in Seattle, with 70.8 % of organizations choosing that category, compared to 47.9 % in Baltimore. "Community Improvement" was the most chosen organizational purpose of environmental stewardship groups in Baltimore, with 50.3 % of respondents compared to 34.7 % in Seattle. Of the 17 remaining categories, Seattle organizations only displayed higher percentages in three: "Animal-related," "Pollution/Toxics," and "Research in science and/or technology." At least 10 % more organizations in Baltimore than in Seattle reported that the following purposes described their organizations very well: "Education," "Youth," "Arts," and "Faith." Thus, more Seattle groups described their purposes in the environmental and science realms, whereas much greater percentages of Baltimore groups expressed social, including faith-driven, purposes. This supports concurrent work in these two cities, which found Baltimore organizations offered faith-based terms and Seattle groups used more nature and wilderness-related terms to define environmental stewardship (Romolini 2013).

Trends were also different across cities in the locations of stewardship activities. Survey respondents were also asked to choose the types of sites on which they conduct stewardship activities. The sites were organized into three categories: Nature in Built Places, Natural Areas and Open Spaces, and Water and Water-related, with more specific site types listed in each category. The results revealed that higher percentages of Baltimore organizations than Seattle organizations reported conducting stewardship activities on eight of the 11 sites in the category "Nature in Built Places." Among the eight site types dominated by Baltimore organizations were "Planter/Flower box" (reported by 30.6 % more Baltimore than Seattle organizations), "Vacant Land/Lot" (reported by 21.4 % more Baltimore than Seattle organizations), "Residential Building Grounds" (reported by 12.6 % more Baltimore than Seattle organizations), and "Public Right of Way" (reported by 11.8 % more Baltimore than Seattle organizations).

In the category "Water and Water-Related," much higher percentages of Seattle organizations reported stewardship activities on each of the four site types. These included 36.3 % more Seattle organizations reporting conducting stewardship activities in a "Wetland," 31.4 % more Seattle organizations reporting working on a "Waterfront/Beach/Shoreline" site, and 22.3 % more Seattle organizations reporting activities on a "Stream/River/Canal" site. The margins were smaller for the response "Watershed/Sewershed," with 57.7 % of Baltimore and 66.7 % of Seattle organizations reporting activities in that site type.

Responses in the category of "Natural Areas and Open Spaces" showed variation between the two cities. Higher percentages of Seattle organizations reported activities in "Forest/Woodland" (30.2 % higher), "Greenways/Bike Path/Trails" (18.7 % higher), and "Prairie/Savanna" (17.6 % higher) site types. The "Park" site type received the highest total response: 83.3 % of Seattle and 72.4 % of Baltimore organizations reported that they conduct stewardship activities in a park. In Seattle, this was the most reported site type. Baltimore's most reported site type was "Community Garden," with 78.5 % of organizations reporting activities there, which was 25.7 % higher than the Seattle response rate. Higher percentages of Baltimore organizations also reported activities in the "Public Garden," "Playing Field/Ballfield," and "Urban Farm" site types.

Thus, while Seattle organizations reported much more activity in water-related site types, Baltimore organizations dominated in reporting activities in sites within built environments. Within the category of natural areas and open spaces, the responses were mixed, with Baltimore organizations reporting more activity in community gardens, and Seattle groups working on more forests and parks. This still reflects a built versus open space divide, as community gardens in Baltimore are often constructed on

reclaimed abandoned land. These differences in site types may be partially explained by the histories of development and industry in each city. For example, Baltimore's legacy of losing industry and population left it with tens of thousands of vacant properties; some of which community groups have used to plant gardens and help revitalize neighborhoods.

Network Characteristics

In the measures of network cohesion, very low densities of less than 1 % were found for both networks, as would be expected. The density measures were virtually identical for both cities across all tie types; Baltimore's network had a 0.62 % density score and Seattle's network had a 0.63 % density. Previous research demonstrates variation in network size affects network cohesion (Friedkin 1991; Moody and White 2003); that is, a smaller network needs a higher level of density than a large one to reflect the same level of cohesion (Friedkin 1981). Indeed, low density is expected in cases of large networks, though these studies are rare in the natural resource governance literature. While the density values provide some information to help understand the networks, the other network measures must be examined to better explain the environmental governance structures of these cities.

Unlike density, the centralization scores were much different in Baltimore and Seattle, with Baltimore displaying over five times greater centralization than Seattle (18.3 and 3.6 %, respectively). These results offer support for polycentricism, as each network was loosely organized around multiple hub organizations, as can be seen in Fig. 2. At 18 % centralization, Baltimore's network is more than five times more centralized than Seattle's. As discussed earlier, high centralization is when a small number of organizations hold most of the ties in the network. One possible explanation for the disparity in centralization is the relative distribution of resources. Of the survey respondents that replied to the financial questions, Seattle stewardship organizations reported average budgets of $23.5 million, which was more than 10 times as large as Baltimore organizations' reported mean of $2.1 million. Looked at through a different metric, the $150,000 median budget reported in Seattle was still over six times that of the $24,000 reported in Baltimore. We posit that the scarcity of funding resources in Baltimore requires organizations to leverage each other's resources more so than Seattle organizations, which may require greater reliance on the most central organizations. We have seen this anecdotally through the Urban Waters Federal Partnership program, an effort that mandates leveraging organizational resources, which has been implemented with great enthusiasm in Baltimore. Benefits of higher centralization include greater opportunity for information to diffuse quickly through the network. By distributing information through just a few main hubs such as those organizations with the top centrality measures, most of the population can be reached. However, highly centralized networks are not always as flexible because many actors are reliant on just a few. If one actor leaves the network, the network can collapse. Conversely, Seattle's low network centralization means the diffusion of information will require more initial effort, but the increased distribution of ties allows for greater involvement of each individual organization in the network.

The next analyses examined actor level network measures of degree and betweenness centrality. Results for degree centrality in both networks revealed a relatively small number of organizations holding a large number of ties. However, this is much more pronounced in Baltimore, with 11 organizations (2.8 % of the network) holding more than one-fifth of the relationships related to information sharing. In fact, the most connected organization in Baltimore, Parks and People Foundation, has 76 ties, which is more than 4 % of the ties in the network. In Seattle, the ties are more evenly distributed. The most connected organization in Seattle, the Seattle Department of Parks and Recreation, only has 40 information ties. In both cities, the majority of organizations are very weakly or not at all connected to the network, with 51 % of the organizations in Baltimore and 52.1 % of the organizations in Seattle reporting having zero or one tie.

In addition to overall measures of degree centrality, outdegree and betweenness centrality were calculated for each city. Figure 2 displays the resulting network diagrams for Baltimore and Seattle, to illustrate differences. Node sizes are relative to the centrality levels and are shaded if they fall into the highest range of degree or betweeenness scores. In many cases, the actors with the largest number of outdegree ties are also those with highest betweenness scores. However, as can be seen in figure, there are several actors with many outdegree ties but a lower betweenness score, and others with fewer outdegree ties but a high betweenness score. To emphasize this further, for each city, we can consider the top 20 organizations with the most outdegree ties (Fig. 2a, b) alongside the 20 organizations with the highest betweenness scores (Fig. 2c, d). As shown in Fig. 2a, c, out of the top 20 organizations in Baltimore with the most ties, only 12 also have the highest betweenness scores, leaving eight organizations that rank high in degree or betweenness centrality but not both. In Seattle (Fig. 2b, d), 13 organizations rank in the top 20 for both degree and betweenness centrality, leaving seven organizations that rank highly in only one measure of connectedness. Another notable result is that several organizations with the top 20 centrality scores did not

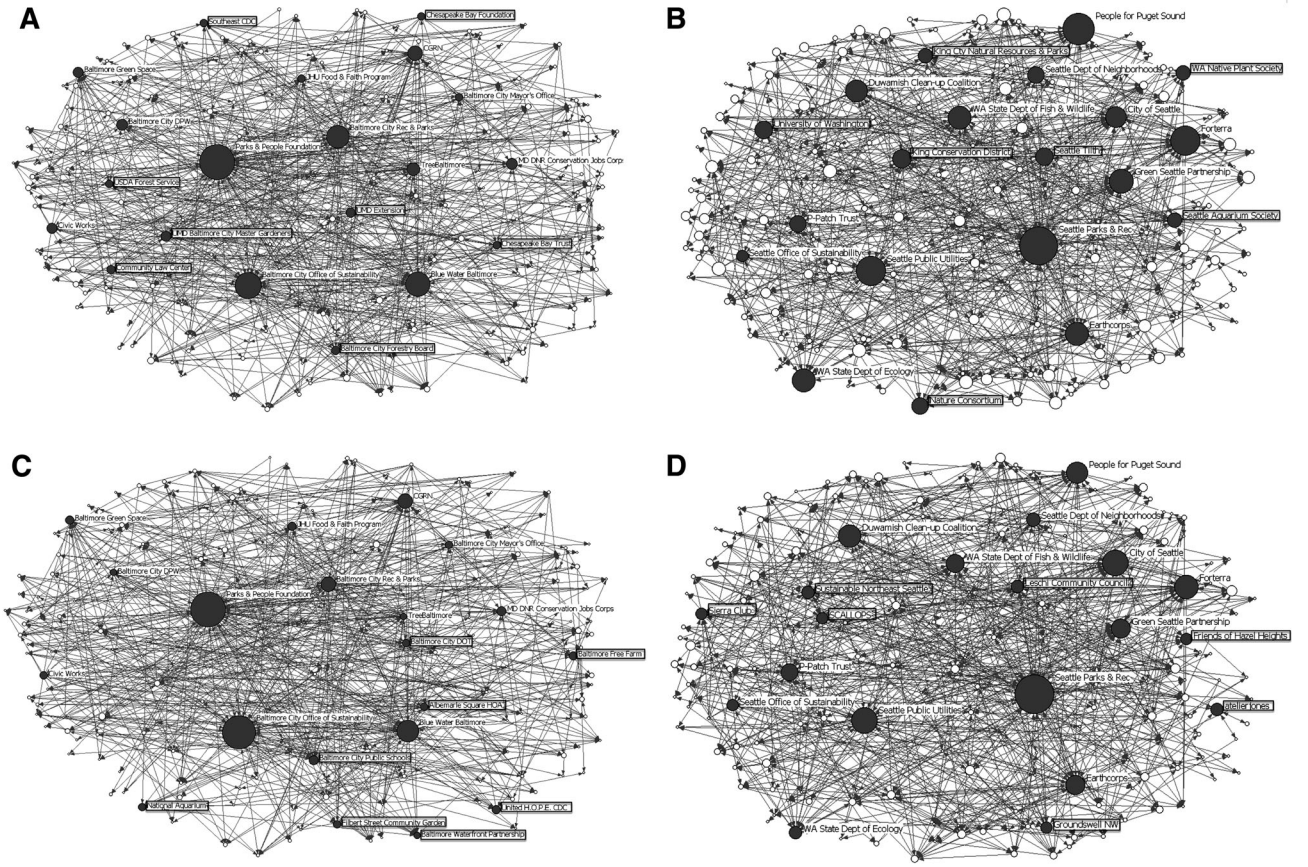

Fig. 2 **a**–**d** Differences in outdegree (*top*) and betweenness (*bottom*) centrality of information ties in Baltimore (**a**, **c**) and Seattle (**b**, **d**) stewardship networks. *Node size* indicates relative centrality score. *Shaded nodes* are within the top twenty for that particular measure. Nodes that only appear in the top twenty for one measure of centrality—outdegree or betweenness—are highlighted with a box around the organization name. Organizations with one or zero ties are not shown on the network diagrams to improve visual clarity

respond to the survey but were captured through imputation. These include five non-respondents in Baltimore—the National Aquarium and Chesapeake Bay Foundation, and the Baltimore City Mayor's Office, Department of Public Works and Department of Recreation and Parks; and four non-respondents in Seattle—King County Natural Resources and Parks, the Washington Native Plant Society, the Seattle Department of Neighborhoods, and Seattle Department of Parks and Recreation.

The differences in degree and betweenness centrality supported our initial reasoning for examining both measures. As described, the central hub organizations can effectively distribute information to the rest of the network, yet their ties are often weak and they may not have as much influence over other members of the network. Actors with high betweenness are believed to have more influence and can diffuse information to the less connected parts of the network. However, their position in between other actors can constrain these organizations to act on one decision. We found the most well-connected organizations were not necessarily the more influential. Further, the top 20 most influential organizations for each city uncovered some surprises. We expected to find organizations such as each city's sustainability offices and related city agencies such as parks and recreation, as well as the prominent non-profits—for example, Blue Water Baltimore and Parks and People Foundation in Baltimore and Forterra and People for Puget Sound in Seattle. Less expected were the smaller organizations such as community councils and development centers, "Friends of" groups, and local community gardens and urban farms that appeared in top 20 most active and influential for both cities. Other examples of unexpected results included the high ranking of aquariums—in Baltimore's most influential and Seattle's most active, an urban planning and design firm in Seattle's top most influential, and a community law center in Baltimore's top most active.

The identification of these most active and influential organizations can have direct applications in practice. Depending on the goals of the knowledge or information distribution, sustainability leaders may find it useful to focus efforts on reaching those with either the most activity

or the most influence. For example, when seeking to "get the word out" about a new stewardship program or project, the motivation might be simply to reach the largest number of organizations. This would be an appropriate time to target the most active organizations. However, if the purpose of the communication is to garner support for a certain policy initiative or to convince organizations to take up a particular stewardship activity, it would make sense to focus on distributing information through those identified as most influential. Practitioners seeking to conduct outreach to the whole network will also need to consider the approximately 12 % of organizations without connections related to information about environmental stewardship. This suggests that additional effort will be needed to reach beyond the well-connected organizations to include a diversity of stakeholders.

Implications and Future Directions

This study contributes to the literature on urban social-ecological governance and policy networks by assessing and comparing the information sharing networks of environmental stewardship organizations in Baltimore and Seattle. This type of large-scale, whole network analysis is not common in the field and yet offers foundational characterizations that can ground future analyses, offer the context for comparative and longitudinal studies that can reveal patterns across networks and over time, and have the ability to inform practice.

The use of data imputation allowed us to begin to address the need expressed by public administration scholars (O'Toole 1997; Koliba 2006; Provan and Kenis 2008) for whole network analyses—in this case two large networks constructed of 390 organizations from 163 respondents in Baltimore and 395 organizations from 144 respondents in Seattle. This whole network analysis provides a vital baseline for beginning to understand how urban social-ecological governance operates. Indeed, this method allowed for identification of several active and influential organizations that did not respond to the survey. Analysis of this more complete representation of the networks revealed that the most well-connected organizations are not necessarily the most influential, which can have clear management implications for how facilitate information and knowledge distribution through these networks. This type of whole network characterization represents a step forward in understanding the environmental governance structures in cities, but there is much more work to be done. Future research should include deeper intra-city analysis, inclusion of more cities for comparison, and longitudinal research to assess how the networks change through time.

An intra-city assessment of stewardship networks provides a level of self-awareness to the organizations within the networks, allowing them the opportunity to adjust management approaches to create and maintain relationships related to information and knowledge distribution. In this way, organizations can be active participants in the adaptive management process. We have already begun to see this in Baltimore, where our data and analyses have informed the Urban Waters Federal Partnership. Network analysis is particularly relevant because the program relies on partners to work together to leverage each other's capacities to improve urban waters. We have presented these findings to several Partnership meetings, which are attended by representatives of community groups, non-profits, academia, and city, state, and federal agencies. Participants were excited to discuss how to best use the data to promote the exchange of information, knowledge, and expertise, match organizations to priority stewardship areas, and promote inclusion of marginal organizations. We encouraged the development of new research questions for us to pursue, with the ultimate goal to help provide participants with information they need to effectively implement projects and to bolster their proposed policy changes. We are pursuing further research opportunities to conduct deeper examination of the top nodes, through individual and group informant interviews to strengthen the reliability of the whole network analysis. Additionally we intend to use the whole network characterization as a foundation for more in-depth examination at smaller scales of analysis. For example, one could assess and compare sub-networks by sector, by function, and by site type. Both the whole network characterization and the sub-network assessments can be of great utility to practitioners in the cities of study.

Inter-city comparisons reveal similarities and differences in network composition and structure. For example, though the overall numbers of stewardship organizations in Baltimore and Seattle were so similar, the differing trends in the purposes, types, and locations of activities imply a need for a nuanced approach to stewardship that is dependent on local circumstances. As these data are compared with similar ongoing studies in New York City, Chicago, Los Angeles, Philadelphia, and San Juan, Puerto Rico, certain characterizations may emerge. This multi-city synthetic research is in progress. For example, an active group of researchers from four of these cities is drawing upon their work to better understand the role of network governance in urban transitions toward sustainability. It is necessary to conduct these cross-city comparisons to contribute to the development of a typology and eventually one unifying theory of governance networks, which has been expressed as a need in the field (Provan et al. 2007) and would be undoubtedly useful to both researchers and practitioners.

Finally, longitudinal research assessing changes in network structure and participation are needed. Most of the cities within this national project have collected stewardship organization data for one point in time, which can allow for some examination of relationships between stewardship and changes in natural resources. For example, a New York study by Locke et al. (2014) examined urban environmental stewardship and 10-year changes in vegetative cover and building footprint, and research using Baltimore and Seattle data looked at relationships between stewardship networks and land cover in those two cities (Romolini et al. 2013a). Yet these studies do not have the ability to directly compare network changes with changes in natural resources conditions. Future research should include plans to collect time series data to offer more detailed insight into network effectiveness as a form of governance. In Baltimore, progress toward this has included preliminary reanalysis of a 1996 network study of organizations involved in natural resources management of a small watershed within Baltimore City (Romolini et al. 2013b) as well as a plans for future network data collection in 2018 to provide a third time point for longitudinal study.

In conclusion, it is in the best interest of municipalities to implement sustainability policies efficiently and effectively. Cities with newly formulated policies may look to established programs to identify best practices. Yet variations in socioeconomic and environmental conditions may affect how or whether certain practices will have the same impact when transferred to another region. It is important to examine the governance networks both within and across cities. This study represents a contribution to the area of urban social-ecological governance by examining the whole networks of stewardship organizations at a citywide level, and by comparing the results across cities. The results can help inform urban stewardship theories, methods, and practice, and they offer an exciting foundation for continued exploration of these systems.

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