Landscape and Urban Planning 120 (2013) 190–207

Contents lists available at ScienceDirect

Landscape and Urban Planning

journal homepage: www.elsevier.com/locate/landurbplan

Assessing and comparing relationships between urban environmental stewardship networks and land cover in Baltimore and Seattle

Michele Romolini[a,*], J. Morgan Grove[b], Dexter H. Locke[c]

[a] Loyola Marymount University, Center for Urban Resilience, 1 Loyola Marymount University Drive, Research Annex 120, Los Angeles, CA 90045, United States
[b] USDA Forest Service Northern Research Station, Baltimore Field Station, , 5523 Research Park Drive, Baltimore, MD, United States
[c] Yale School of Forestry and Environmental Studies, 195 Prospect Street, New Haven, CT 06511, United States

HIGHLIGHTS

- We explore environmental stewardship network structures in Baltimore and Seattle.
- We combine network and spatial analyses to assess network/land cover relationships.
- We find higher incomes and more groups in well canopied neighborhoods in Baltimore.
- Home ownership is the principal explicator of tree canopy in Seattle.
- We suggest enhanced methods for continued study of stewardship causes and outcomes.

ARTICLE INFO

Article history:
Received 21 March 2013
Received in revised form 9 August 2013
Accepted 14 August 2013

Keywords:
Urban ecology
Stewardship
Environmental governance
Cross-site analysis
Social network analysis
Spatial analysis

ABSTRACT

Implementation of urban sustainability policies often requires collaborations between organizations across sectors. Indeed, it is commonly agreed that governance by environmental networks is preferred to individual organizations acting alone. Yet research shows that network structures vary widely, and that these variations can impact network effectiveness. However, largescale studies of environmental network structure and outcomes are rare. Little research exists that evaluates whether local environmental conditions impact network structure, and whether the structure, or even the existence of a network has measurable impact on local conditions. These research gaps may be partially attributed to methodological challenges in studying networks across geographic space. This study addresses these challenges and examines the question, "what are the relationships among environmental conditions and environmental stewardship networks in Baltimore and Seattle, and how do these two cities compare?" We surveyed environmental stewardship organizations in each city to collect data about organizational relationships and locations of stewardship activities. Social network and spatial regression analyses were applied to these data to explore relationships among variations in neighborhood land cover and network measures. Land cover was not found to be a strong predictor of organizational presence or network structure in either city. However, both the number of organizations and the number of ties between them correlated significantly with the percentage of tree canopy in Baltimore neighborhoods. Seattle had similar trends, but the relationship appeared weaker. Findings contribute to the nascent field of urban environmental stewardship, and thus results are discussed in relation to their ability to inform future research.

1. Introduction

In this paper, we present findings from a study that assessed relationships among land cover and stewardship networks in Baltimore and Seattle, both within and across these cities. Specifically, we asked the question, "what are the relationships among environmental conditions and environmental stewardship networks in Baltimore and Seattle, and how do these two cities compare?" This research was driven by a number of theoretical, methodological, and practical motivations, and the results contribute to the growing field of urban environmental stewardship research.

First, we sought to inform the development of a theory of urban environmental stewardship networks. The urban fabric is fragmented into many parcels under different uses and ownerships, producing a large, diverse group of stakeholders with an interest in resource management decisions (Svendsen & Campbell,

* Corresponding author. Tel.: +1 3103385104.
E-mail addresses: michele.romolini@lmu.edu, mromolini@gmail.com (M. Romolini), jmgrove@gmail.com (J.M. Grove), dexter.locke@gmail.com (D.H. Locke).

0169-2046/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.landurbplan.2013.08.008

2008). Environmental stewardship organizations are actors of particular interest because they interact with both natural resources and the social system (Svendsen, 2010). Stewardship groups can be any combination of non-profit, state, and private sector stakeholders working to conserve, manage, monitor, advocate for, and educate the public about their environments (Fisher, Campbell, & Svendsen, 2012; Svendsen & Campbell, 2008). An emergent body of urban stewardship research includes work in New York City, where 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, Svendsen, Fisher, & Campbell, 2013). In Seattle, pilot stewardship research efforts have resulted in an organizational census of stewardship organizations in the Puget Sound Region (Wolf, Blahna, Brinkley, & Romolini, 2013) and the development of a practitioner-derived conceptual framework of urban environmental stewardship (Romolini, Brinkley, & Wolf, 2012; Wolf et al., 2013). In Chicago, researchers found that geographic proximity of office location and field sites increased interactions among stewardship organizations (Belaire, Drilbin, Johnston, Lynch, & Minor, 2011). To date, there have been no empirical cases of how stewardship networks relate to the environments in which they operate, as measured through biophysical features in the cityscape.

Next, addressing the posed research questions required methodological developments, including a unique combination of social network and spatial data for analyses. In recent years, some researchers have directed their attention to the application of social network analysis to better understand collaboration in social–ecological systems (Crona & Bodin, 2006; Ernstson, Sorlin, & Elmqvist, 2008; Lauber, Decker, Knuth, & 2008; Muñoz-Erickson et al., 2010). Relevant examples include using network analysis to categorize and assess stakeholder relationships in resource management (Prell, Hubacek, & Reed, 2009), to evaluate social capital in collaborative planning (Mandarano, 2009), and to examine structure (Schneider, Scholz, Lubell, Mindruta, & Edwardsen, 2003) and effectiveness (Laven, Krymkowski, Ventriss, Manning, & Mitchell, 2010) of networks facilitated by federal programs. Research (cf. Bodin & Crona, 2009) suggests that the structure of an organizational network matters in natural resource governance. The values of certain structural measures, such as network density and network centrality, may affect network qualities such as adaptive capacity, learning, and trust, which are known to be important for adaptive management of natural resources (Bodin, Crona, & Ernstson, 2006). Yet there has been little research examining the relationship between network structures and on-the-ground measures of effectiveness, or outcomes (Provan & Milward, 2001).

Particularly in urban areas with a mosaic of multiple land uses and varying definitions of boundaries, researchers face methodological challenges in combining network analysis with analyses of variations in local social and ecological conditions. With this study we address this obstacle by capturing the geographic scope, defined at the neighborhood scale, of each organization's stewardship activities. Social network analyses of spatially explicit data make it possible to link stewardship presence and activity, network relationships, and associated neighborhood-level environmental variables such as land cover. Methodological advances combining these approaches can provide insight into how variations in network structures are associated with variations in land cover, generating the opportunity to understand social–ecological governance structures and related outcomes in a novel way.

Finally, assessing stewardship networks in urban areas is also of practical importance. In the US, the population continues to move to cities, with over 82% of the population now residing in urban areas (United Nations, 2012). As urbanization takes on new scales, rates, locations, forms, and functions (Seto, Sánchez-Rodríguez, & Fragkias, 2010), cities must not only adapt to the resulting ecological and social changes, but also anticipate and respond to future changes. This may require a shift in governance towards the adaptive management strategies best provided by mixed-form networks. Managing or actively fostering these networks may be facilitated by a basic understanding of the relationships among environmental features and network presence, structure, and variation. Few studies have focused on the networks that operate in urban social–ecological systems, with scholars such as Ernstson, Barthel, Andersson, and Borgström, 2010 acknowledging and seeking to address this research need (Ernstson et al., 2010). In this study, we conduct both intra-city and inter-city comparisons of stewardship networks and land cover. Intra-city neighborhood-scale stewardship network comparisons provide assessments across urban and socio-demographic gradients, while inter-city comparisons of environmental governance structures will bolster interpretations of outcomes, and provide a basis for the development of best practices for urban stewardship networks. Our research represents the first inter-city comparative study within a national urban stewardship research program conducted by the USDA Forest Service and partners (see, for example: www.stewmap.net). This multi-city research offers the opportunity to compare environmental network structures and outcomes in urban areas across the country. The success of such networks of environmental stewards could be key to advancing sustainability of cities. Further, a heightened understanding of network structure, function, location, and outcomes could contribute to the likelihood of their success.

2. Methods

2.1. Study sites: Baltimore, MD and Seattle, WA

The cities chosen for this study were Baltimore, MD and Seattle, WA. Table 1 displays some characteristics of the two metropolises that make them particularly well suited for cross-site analyses. Baltimore is located in the Mid-Atlantic region of the US, and is an older, post-industrial, majority Black, less wealthy, less educated city with declining population. In contrast, Seattle is located in the Pacific Northwest, and it is a younger, majority White, wealthier, highly educated city with rising population. These socioeconomic and historical differences are striking and likely to impact both the land cover and stewardship variables examined in this study. Yet there are many similarities that provide a foundation for comparison. The population and land areas of the cities are nearly

Table 1
Socioeconomic and environmental conditions in Baltimore and Seattle.

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)[b]	83.0	80.8
% Tree canopy cover[c,d]	28.1	27.4
Impacted water body	Puget Sound	Chesapeake Bay
No. of neighborhoods[e,f]	93	271
No. of groups engaged in environmental stewardship activities[g]	568	607
No. of survey respondents (response rate)	144 (25.4%)	163 (26.9%)

[a] 2010 US Census.
[b] 2000 US Census.
[c] Land use/land cover, Seattle, WA 2009.
[d] Land Cover, Baltimore, MD 2007.
[e] cityview.baltimorecity.gov.
[f] http://clerk.seattle.gov/public/nmaps/fullcity.htm.
[g] Romolini (2013).

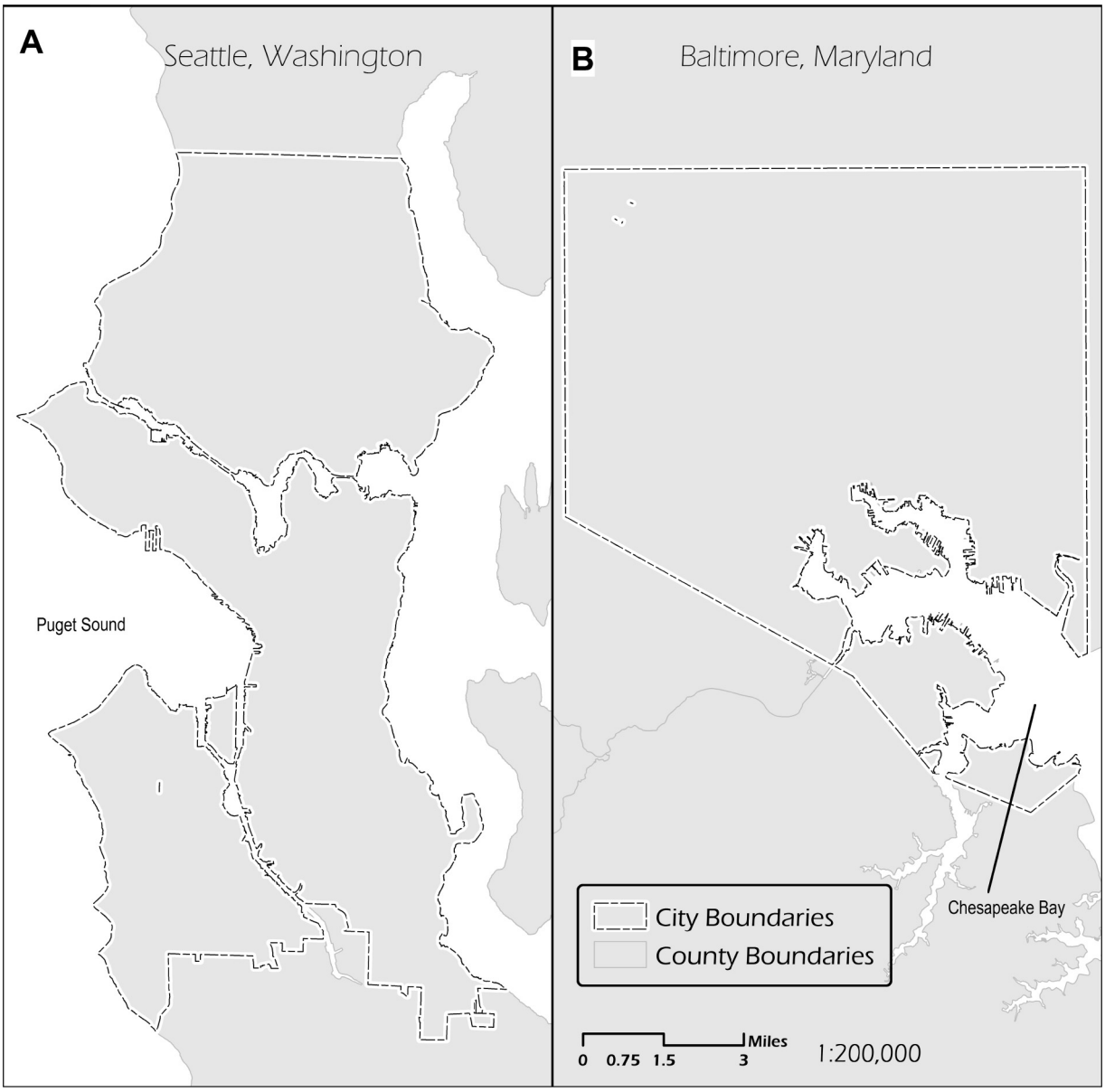

Fig. 1. Seattle and Baltimore have nearly the same size population and physical size. Both are also situated in heavily impacted estuarine systems: the Puget Sound and the Chesapeake Bay.

identical (Fig. 1). The two cities show similarities with respect to resource condition and management. They have similar amounts of tree canopy cover, and each has programs to increase tree cover over a period of several decades. Both are situated in heavily impacted estuarine systems: the Puget Sound and the Chesapeake Bay. Watersheds have become administrative and geographic organizing units for public environmental action. For example, both are listed with the EPA's National Estuary Program, which provides funding and technical guidance for estuarine management, and encourages and supports collaborative networks. This federal attention can prompt local action and awareness. Finally, both Baltimore and Seattle are made up of a number of neighborhoods, each with their own defining characteristics. However, despite having land areas that only differ by a few square miles, the two cities are divided into a considerably different number of self-defined neighborhoods (Fig. 2). Baltimore City identifies 271 individual neighborhoods, whereas the city of Seattle identifies 93 neighborhoods.

2.2. Research questions and hypotheses

This study aims to understand the relationships among environmental conditions and urban environmental stewardship networks in Baltimore and Seattle through the following two research questions and associated hypotheses:

Question 1: How does variation in land cover predict and explain the variation in the observed network in both cities; and conversely, how does network presence or structure relate to environmental conditions?

Hypothesis 1a. Increased presence of tree canopy, vegetation, and water will correlate with increased presence of stewardship organizations, greater number of ties between organizations, and denser networks.

With this hypothesis, we sought to begin to build evidence towards a better understanding of how environmental conditions might lead to network formation, which is generally unexplored in

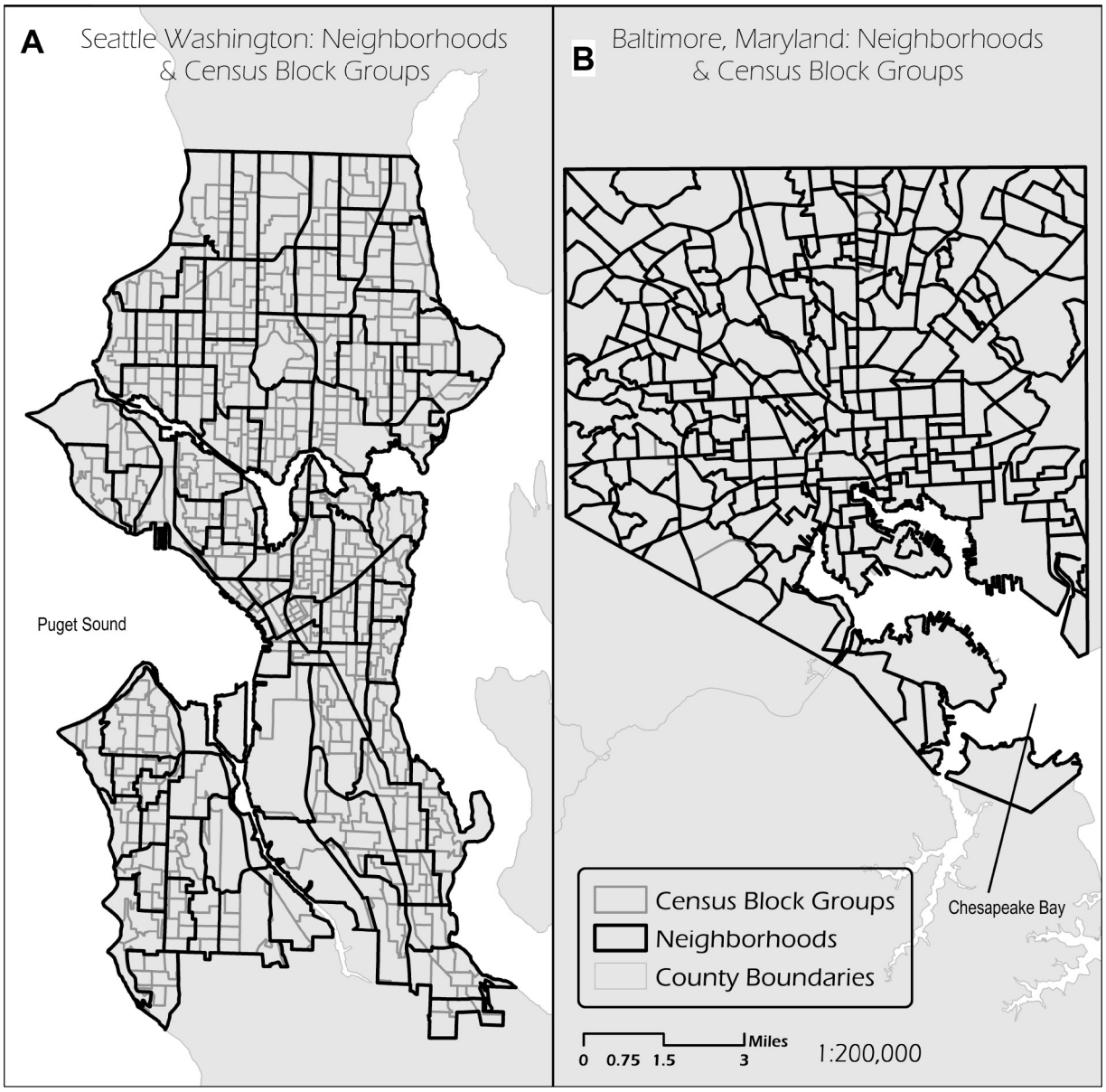

Fig. 2. Seattle and Baltimore have a different number of self-identified neighborhoods, and those boundaries may or may not align with Census block group boundaries.

the literature. It is anticipated that neighborhoods with greater natural resources also tend to have a greater number of stewardship organizations with increased collaboration among them. While certain types of stewardship such as advocacy and education can occur in places with few natural resources, one cannot manage, conserve, or monitor a resource that is not yet present. Therefore, areas with more tree and vegetative cover, and water resources will be more likely to co-occur in neighborhoods with a larger number of organizations and networks working to steward those resources, after accounting for social and spatial correlates.

Hypothesis 1b. Higher numbers of stewardship organizations, greater number of ties between them, and denser networks will correlate with greater tree canopy cover.

With this hypothesis, we sought to begin to build evidence towards a better understanding of how network structure may impact environmental conditions. Collaborative management of natural resources is thought to lead to more effective management of those resources. Preliminary unpublished results in New York City suggest a positive relationship between the presence of stewardship groups and tree canopy over time. The literature also suggests positive relationships between network density and joint action for natural resource management (Bodin & Crona, 2009). Thus, we hypothesized that neighborhoods with more groups, a higher number of ties between them, and denser networks of stewardship organizations would be more likely related to a greater abundance of tree canopy. Urban trees generally require a spectrum of environmental stewardship actions such as planting and ongoing maintenance, which requires the work of many different types of stewardship organizations.

Question 2: How do the relationships among land cover and stewardship networks compare in Baltimore and Seattle?

Hypothesis 2. Baltimore and Seattle will have similar trends in the relationships among land cover and stewardship networks.

Despite socioeconomic differences found in the two cities, it is expected that similar land cover patterns will have similar relationships with stewardship organizational presence and their networks across cities. The reasoning supporting Hypotheses 1a and 1b is

Table 2
Variable names and descriptions. All variables are summarized at neighborhood level (Seattle, $N = 93$; Baltimore, $N = 271$).

Variable name	Variable description	Mean		Standard deviation		Moran's I^*	
		Seattle	Baltimore	Seattle	Baltimore	Seattle	Baltimore
ORGCOUNT	Number of organizations self-identifying as conducting stewardship[a]	5.398	1.749	2.667	2.054	0.430	0.329
NUMTIES	Number of ties between stewardship organizations[a]	2.796	0.753	2.906	2.463	0.020	0.429
DENSITY	Number of existing ties divided by number of possible ties[a]	0.109	0.055	0.130	0.170	0.200	0.168
CAN_P	Percent area covered by tree canopy[b,c]	26.323	25.552	13.347	16.34	0.420	0.69
GRASS_P	Percent area covered by grass & shrubs[b,c]	11.426	20.156	5.645	10.515	0.415	0.322
WATER_P	Percent area covered by water[b,c]	0.540	0.395	3.126	1.646	0.015	0.04
POPD	Population density by square mile[d]	7997.372	11,585.799	4368.502	8505.401	0.416	0.235
P_WHITE	Percent of population identifying as White or Caucasian[d]	0.696	0.26	0.225	0.319	0.819	0.453
P_OWNEROCC	Percent of occupied housing units that are owner occupied[d]	0.495	0.461	0.209	0.268	0.477	0.266
P_EDU	Percent of population 25 years or older with a HS diploma or higher education[d]	0.882	0.61	0.104	0.265	0.676	0.248
P_HIGHINC	Percent of population with income above $50k[d]	0.474	0.254	0.142	0.178	0.391	0.369

* Using a first order queen contiguity matrix.
[a] Romolini (2013).
[b] Land use/land cover, Seattle, WA 2009.
[c] Land Cover, Baltimore, MD 2007.
[d] 2000 US Census.

expected to hold in both Baltimore and Seattle, despite the underlying differences of these two urban areas.

2.3. Data sources and rationale

The data used for this study are summarized in Table 2, and were collected and compiled from several sources. In 2011, two 22-question web surveys were conducted of stewardship organizations in Baltimore and Seattle (detailed in Appendix A). Following early urban environmental stewardship work in New York City (Svendsen & Campbell, 2008), a stewardship organization was defined broadly as a non-profit, public, or private organization whose work contributed to "conserving, managing, caring for, monitoring, advocating for, or educating about local environments." The sampling population was derived from a census of organizations conducted in each city in 2009–2010, which identified 607 environmental stewardship organizations in Baltimore and 568 in Seattle (Romolini, 2013). Data were collected and examined at the neighborhood level. Neighborhood differentiation is quite apparent in urban areas, making them a useful unit of analysis for social processes (Sampson, Morenoff, & Gannon-Rowley, 2002). As reviewed by Sampson et al. (2002), neighborhood research has shown significant spatial clustering of such social characteristics as child and adolescent outcomes, health indicators, crime, home ownership, ethnic heterogeneity, concentration of affluence, and others.

In this study, "neighborhood" was defined based on boundaries established by each city's planning department, with the assumption that these would be the most familiar to the participants in the web survey and thus would produce the most accurate data. In both places, the neighborhood boundaries were developed by the city, incorporated community input, and in the case of Baltimore, generally conformed to the Census' Neighborhood Statistical Area, which is an aggregate of Census block groups. In addition, survey takers were provided with an online resource so that if they did not know the name of the neighborhood where they worked, they could easily click a link within the question and view a searchable map. In Baltimore, the resource provided was the public, interactive map available at: cityview.baltimorecity.gov. In Seattle, the public neighborhood map was provided, which is available at: http://clerk.seattle.gov/public/nmaps/fullcity.htm. Each city's survey contained a page with check boxes next to neighborhood names that were hot linked to that neighborhood on the respective online map (see Appendix A for full survey).

Two methods were used to spatially characterize the stewardship networks. In the first case, respondents were given a checklist and associated map of all the neighborhoods in their city and were asked to indicate in which neighborhoods they conducted stewardship activities. In the second case, respondents were asked to provide written descriptions of the boundaries where they worked. These written descriptions can be used later to derive more precise boundaries of stewardship activities. Only the spatial data from the given checklist and map were used in this analysis.

Network analyses of survey data produced three variables measuring stewardship organizations and networks: a count of number of organizations per neighborhood, number of ties per neighborhood, and density for each neighborhood network. The count was a summary of respondents who indicated working in a given neighborhood, which allowed us to measure stewardship presence and the size of the network in each neighborhood. Network variables were based on responses to four questions about surveyed organizations' funding and information relationships with other organizations. These four questions were collapsed and entered into a binary, directed matrix, where an actor could have a total of two ties with another. Calculations were then conducted using the social network analysis software UCINET (Borgatti, Everett, & Freeman, 2002) to determine number of ties and density (number of ties divided by total possible ties) at the neighborhood level. These variables provided measures of the overall amount and density of relationships between stewardship organizations in each neighborhood. The literature generally describes a positive relationship between density and joint action for natural resource management (Bodin & Crona, 2009). Network density may enhance development of knowledge and understanding through exposure to new ideas and an increased amount of information (Bodin & Crona, 2009), and even at lower densities, there may still be a positive relationship between density and knowledge development (Sandström, 2008). Furthermore, it has been shown that urban stewardship organizations with shared field sites tend to have more relationships both with each other and with outside organizations (Belaire et al., 2011). Thus, network density may be considered an important variable in evaluating how stewardship networks and tree canopy are related. Together, organization count, number of ties, and density

were included to examine the effects of stewardship presence, level of collaboration, and density of collaboration.

Land cover data included vegetation and water coverage summarized to the neighborhood level. These data were acquired from the University of Vermont's Spatial Analysis Laboratory and the University of Washington's Remote Sensing and Geospatial Applications Laboratory, for Baltimore and Seattle, respectively. In Baltimore, the data came from a high resolution land cover data set for Baltimore City derived from year 2007, 1-m resolution color infrared imagery sourced from the National Agricultural Imagery Program (NAIP) along with surface models generated from light detection and ranging (LiDAR) data. The imagery and LiDAR were integrated into an object-based image analysis (OBIA) system in Definiens eCognition software. The user's and producer's accuracies for the tree canopy class were 95% and 92% respectively (Land Cover Baltimore MD, 2007; see also O'Neil-Dunne, 2009, for more details and summaries by land use). For Seattle, the data were taken from a classification created using 2009 NAIP imagery, also 1-m resolution, and 2003 aerial LiDAR. In addition, City of Seattle vector layers for buildings, roads, and water edges were used in the classification. The data were reclassified to match Baltimore's land cover classes, which contain:

1. Tree canopy
2. Grass/shrub
3. Bare soil
4. Water
5. Buildings
6. Transportation (Roads/Railroads), and
7. Other paved surfaces

The user's and producer's accuracies for the tree canopy class were 75% and 80%, respectively (Land Use/Land Cover Seattle WA, 2009; Moskal, Styers, & Halabisky, 2011).

Finally, socioeconomic and demographic variables from the 2000 US Census were included in a preliminary correlation analyses between these variables and canopy cover, and later in the spatial regressions (Tables 3a and 3b). Measures of education and income are proxies for knowledge, status, and power, which have been theorized to play important roles in natural resource management (Burch & DeLuca, 1984; Grove & Burch, 1997; Machlis, Force, & Burch, 1997). Population density serves as a control for urbanicity or "urban-ness." Empirically, these factors plus the percent of owner occupied homes have been significant in other studies (e.g., Boone, Cadenasso, Grove, Schwarz, & Buckley, 2009; Grove et al., 2006; Landry & Chakraborty, 2009; Pham, Apparicio, Séguin, Landry, & Gagnon, 2012; Raddatz & Mennis, 2012; Troy, Grove, O'Neil-Dunne, Pickett, & Cadenasso, 2007; Zhou, Troy, Grove, & Jenkins, 2009). Therefore, the following social variables are included population density, racial composition, home ownership, education, and income. Even though the stewardship network and land cover variables analyzed were closer in time to 2010, data from the 2000 Census were used in this study. This choice was made because the Census long form has almost completely been replaced with the American Community Survey, which has much smaller samples and larger margins of error, making it problematic at fine geographic scales.

2.4. Regression analyses

To test the hypotheses stated in Question 1 above, spatial regressions were applied to the network, environmental, and social variables. Hypothesis 1a posits that increased presence of natural resources will be correlated with stewardship organizations and denser networks. The analyses for this hypothesis included three regression models with each of the network variables as the dependent variables, and several social and environmental independent variables. To address Hypothesis 1b, tree canopy was used as the dependent variable, with the network and several social variables as the independent variables. The independent stewardship variables included: number of organizations (OrgCount), the number of ties between organizations (NumTies), and the density of ties in each neighborhood (Density). Social variables included measures of population density (PopD), race (P_White), home ownership (P_OwnerOcc), education (P_Edu), and income (P_HighInc).

In these types of regression analyses, there is a possibility of spatial autocorrelation, as measurements taken from geographically close positions are often more similar than those taken from more widely separated locations (Ward & Gleditsch, 2008). Spatial autocorrelation is the extent to which a variable is correlated with itself across space. Prior to regression, the Spearman's correlation coefficient, *rho*, was tabulated for all variables within each city. The Moran's *I* was calculated for measuring spatial autocorrelation using Open GeoDa 1.2.0 (Anselin, Syabri, & Kho, 2006). In this measure of spatial autocorrelation negative one indicates completely scattered phenomena, zero indicates complete spatial randomness, and one indicates a clustered spatial pattern (Moran, 1948). For these calculations, a queen spatial weights matrix was created, which is a contiguity-based weighting that defines a location's neighbors as those with either a shared border or vertex. A first order queen matrix was chosen to follow the work of others at similar spatial scales (Pham et al., 2012; Raddatz & Mennis, 2012) and because the polygons delineating neighborhoods form a fairly regular arrangement, approximating a uniform mosaic.

The tree canopy was spatially autocorrelated in both cities, with Moran's *I* of 0.42 and 0.69 for Seattle and Baltimore, respectively. From the outset it was also expected that the network variables would display spatial autocorrelation (see Table 2). This assumption followed the observation that when survey respondents reported stewardship activities in more than one neighborhood, these were often adjacent locations. Given these autocorrelations, a classic ordinary least squares regression (OLS) would likely conflate spatial distributions with other correlates (Ward & Gleditsch, 2008). Further, spatial dependencies violate requisite statistical assumption of independence. We therefore analyzed the data using both spatial lag and spatial error regressions, which incorporates spatial weighting through the contiguity matrix to adjust for known spatial dependencies and produces more robust results (Ward & Gleditsch, 2008). In the case of the spatial error model this effect is represented by lambda (λ), in the spatial lag model the weighted *y* (or *Wy*) models this effect. However, OLS models were specified after performing the correlations so the effects of multi-collinearity could be assessed, in part because of the occasionally high bivariate correlation coefficients. In Baltimore, the variance inflation (VIF) factor never exceeded 4.5, while the Seattle models displayed slightly higher collinearity. The percent high income had a VIF of 7.6, likely attributable to the smaller sample size.

3. Results

Hypothesis 1a. Increased presence of trees, vegetation, and water will correlate with increased presence of stewardship organizations, greater number of ties between organizations, and denser networks.

Tables 3a and 3b show correlations matrices for all variables in each city, the percent tree canopy and the number of organizations per neighborhood are shown in Fig. 3. When Spearman's *rho* is greater than 0.5, the cells are highlighted. High income co-varied with the percent white population, the percent owner occupied

Table 3a
Spearman's correlation coefficient (*rho*) among all variable for Baltimore.

	OrgCount	NumTies	Density	Can_P	Grass_P	Water_P	PopD	P_White	P_Owner	*P*_Edu	*P*_High
OrgCount	1										
NumTies	0.61***	1									
Density	0.59***	0.99***	1								
Can_P	−0.15**	−0.23***	−0.22***	1							
Grass_P	−0.24***	−0.25***	−0.24***	0.49***	1						
Water_P	−0.02	−0.06	−0.07	0.21***	0.18**	1					
PopD	0.15**	0.2**	0.19**	−0.36***	−0.41***	−0.49***	1				
P_White	0.26***	0.25***	0.24***	0.07	−0.08	−0.14**	0.11*	1			
P_Owner	−0.04	−0.02	−0.02	0.24***	0.23***	−0.1*	0.14	0.46***	1		
P_Edu	0	0.07	0.07	0.43***	0.17**	−0.14**	0.09	0.61***	0.55***	1	
P_High	0.04	0.07	0.07	0.37***	0.21***	−0.09	0.08	0.65***	0.73***	0.84***	1

* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level, values > 0.5 shown in gray.

Table 3b
Spearman's correlation coefficient (*rho*) among all variables for Seattle.

	OrgCount	NumTies	Density	Can_P	Grass_P	Water_P	PopD	P_White	P_Owner	P_Edu	P_High
OrgCount	1										
NumTies	0.72***	1									
Density	0.18*	0.68***	1								
Can_P	−0.06	−0.03	−0.04	1							
Grass_P	0.04	0.04	0.11	0.5***	1						
Water_P	−0.07	−0.18*	−0.26**	−0.02	0.05	1					
PopD	−0.09	−0.13	0	−0.32***	−0.44***	−0.24**	1				
P_White	0	−0.01	−0.13	0.14	−0.29***	0.1	−0.01	1			
P_Owner	0.11	0.2*	0.08	0.62***	0.46***	−0.05	−0.55***	0.27***	1		
P_Edu	−0.2*	−0.1	−0.08	0.31***	−0.1	0.22**	−0.02	0.82***	0.3***	1	
P_High	0.02	0.1	−0.03	0.54***	0.11	0.08	−0.36***	0.64***	0.79***	0.68***	1

* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level, values > 0.5 shown in gray.

housing as well as educational attainment. Education and the white population also significantly correlated across both study sites.

As shown in Table 4, the results of all three lag and error models failed to reject the null hypothesis in Baltimore. No significant relationships were found among the land cover variables and any of the three organizational and network variables. The P_White variable had a significant positive relationship with all three organizational and network variables, with the exception of the error model for NumTies (Table 4). The R^2 values ranged from 0.14 to 0.38 for the three analyses in Baltimore. The Seattle results (Table 5) show a few small but significant relationships found among land cover and the network variables in the error models, with the results indicating that every 1% increase in tree canopy correlated with an increase of 0.05 stewardship organizations, or a 20% increase in canopy corresponded with one additional stewardship organization. Grass_P also had a positive relationship with OrgCount; a 10% increase in grass cover correlated with one additional stewardship organization. Conversely, a negative relationship was found between tree canopy and NumTies, with each 20% increase in tree canopy corresponding to one fewer tie among organizations. The only other significant relationship found in Seattle was between owner occupied housing and number of ties, with a 1% increase in owner occupied housing corresponding with about seven more ties between organizations. The R^2 values spanned a low to moderate range, from 0.10 to 0.45. The modest fit of the models is illustrated by the significance levels of the intercept; only organizational count displayed statistically significant relationships in Baltimore models and only NumTies in the error model in Seattle.

Hypothesis 1b. Higher numbers of stewardship organizations, greater number of ties between them, and denser networks will correlate with greater tree canopy cover.

Table 6 shows the results of the spatial lag and error regression analyses for Baltimore and Seattle, with percent tree canopy cover (Can_P) as the dependent variable. The results were far more robust in this analysis, with R^2 values of 0.69–0.71 in the Baltimore and 0.58 in the Seattle regression models.

There were a number of significant relationships among the independent variables and the percent tree canopy cover (Table 6). Most relevant to the research hypothesis, the number of organizations (OrgCount) was positively related and the number of ties between organizations (NumTies) was significantly and negatively associated with the percent tree canopy cover in the Baltimore spatial regression models. The number of stewardship organizations was positively associated with tree canopy, with the results indicating an increase of about 1% in tree canopy with the addition of one stewardship organization. In contrast, the number of ties between organizations (NumTies) had a negative relationship with tree canopy cover, with the results showing a decrease of nearly 1% in tree canopy with every additional tie between organizations. Income was the greatest predictor of tree canopy in Baltimore, while number of ties and population density exhibited a negative and significant relationship with tree canopy in both Baltimore models. In Seattle, the error model produced similar results in the tree canopy and OrgCount relationship, showing a 1.25% increase in tree canopy with each additional stewardship organization present. Seattle neighborhoods with greater home ownership tended to have more tree canopy. The Akaike Information Criterion (or AIC), a log-penalized maximum likelihood estimator (Akaike, 1978), was far lower in Seattle when compared to Baltimore, suggesting a more parsimonious model even if it has 11% less explanatory power.

Hypothesis 2. Baltimore and Seattle will have similar trends in the relationships among land cover and stewardship networks.

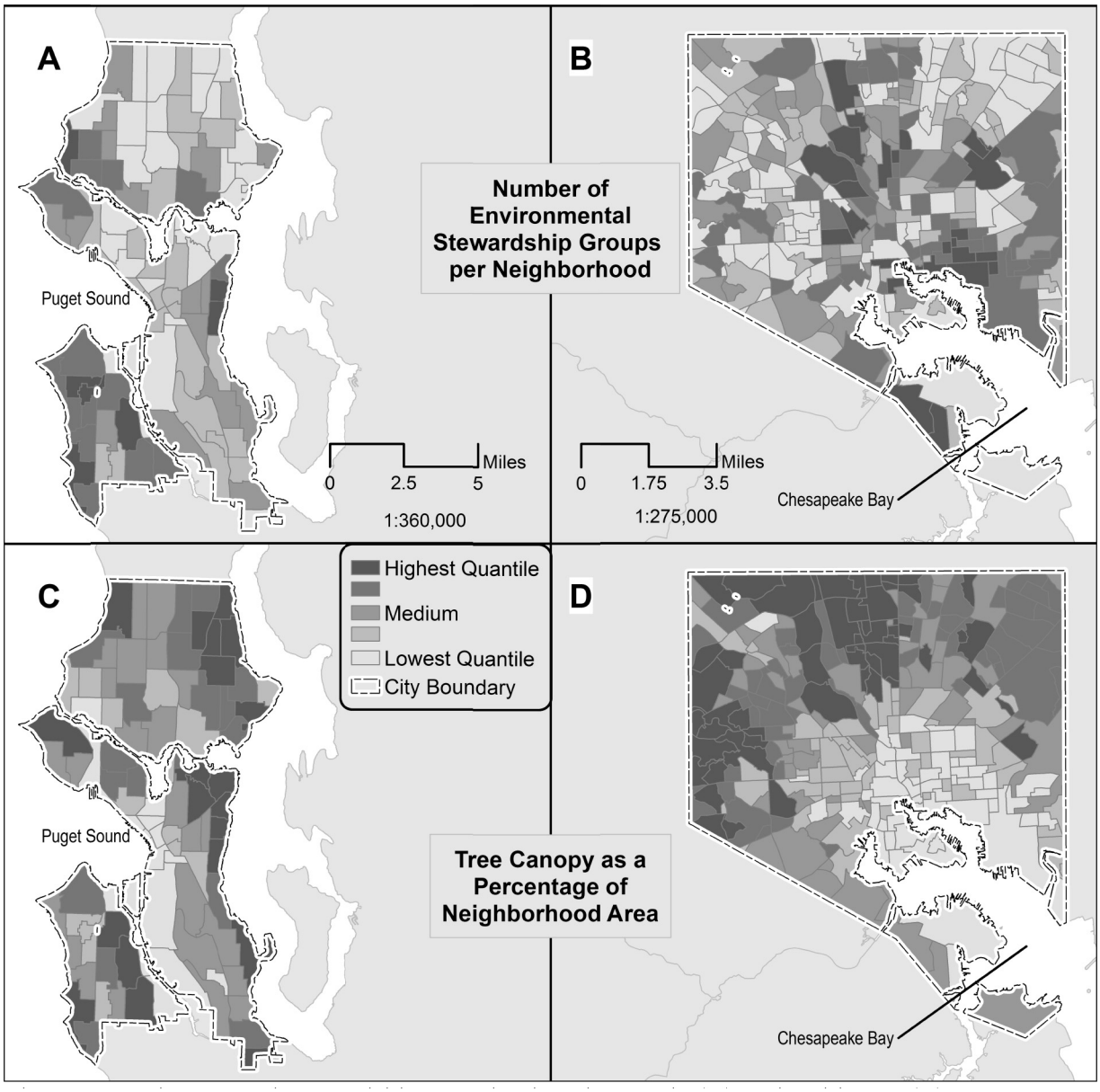

Fig. 3. Environmental stewardship organizations in Seattle (A) and Baltimore (B) per neighborhood have a similar degree of positive spatial autocorrelation (Moran's *I* of 0.43 and 0.329, respectively). The percentage of tree canopy, however, exhibits less spatial autocorrelation in Seattle (C, Moran's $I = 0.42$) than in Baltimore (D, Moran's $I = 0.69$). The number of stewardship groups in Seattle bears little correlation with tree canopy (Spearman's $rho = -0.06$, not significant at a 10% level), whereas there is a minor negative correlation between stewardship groups and tree canopy in Baltimore (Spearman's $rho = -0.15$, significant at a 5% level). In all cases a first-order queen contiguity matrix was used in calculating the Moran's *I*.

The results from the first Hypothesis 1a indicated similar trends among land cover and stewardship presence or networks in Baltimore or Seattle. Specifically, no significant relationships were found in Baltimore, and small associations were found in Seattle but at low levels of confidence. The results from the second Hypothesis 1b demonstrated different trends for Baltimore and Seattle. In the case of Baltimore, both the number of organizations and the number of ties between organizations were significantly related to the percent tree canopy cover. In contrast, we did not find evidence for these contextual multivariate correlations in Seattle when using spatial lag regression techniques. However, in Seattle, the bivariate correlations between tree canopy and home ownership (Spearman's $rho = 0.62$) and between tree canopy and high income (Spearman's $rho = 0.54$) are highly statistically significant. In Baltimore those same pairwise comparisons yielded more modest associations. In Baltimore, income and population density also were significantly related to tree canopy; in Seattle, percent of housing units that are owner occupied had a significant relationship to tree canopy.

4. Discussion

The aim of this study was to examine relationships among environmental stewardship networks and land cover in the neighborhoods of Baltimore and Seattle. As the first known study utilizing the methods employed here, this was a preliminary study in a large research project. Thus, this section will discuss the findings in the context of suggested areas for future research.

SUGGESTION 1: Collection of more detailed data, both qualitative and long term.

Table 4
Spatial lag and spatial error regression results for the research question, "does variation in neighborhood environmental conditions predict the resulting stewardship networks in Baltimore?" $N = 271$.

Variable	y = OrgCount		y = NumTies		y = Density	
Model type	Lag	Error	Lag	Error	Lag	Error
Wy	0.43676***		0.62648***		0.38501***	
Intercept	0.83079*	1.32493**	−0.03233	0.15394	−0.00685	0.02833
Can_P	−0.00028	0.00215	−0.01198	−0.01236	0.00015	0.00008
Grass_P	−0.00291	−0.00024	0.01370	0.01919	−0.00038	−0.00082
Water_P	0.02641	0.00135	−0.01512	−0.02529	−0.00054	0.00136
PopD	0.00003*	0.00001	−0.00000	−0.00001	−0.00000	0
P_White	1.2602***	1.32468**	0.96969**	0.86845	0.10269***	0.11399**
P_OwnerOcc	−0.62902	−0.89752	−0.04161	−0.19558	−0.01687	−0.03178
P_Edu	−0.70128	−0.12302	0.13189	0.60464	0.06368	0.06338
P_HighInc	0.69734	0.63965	−0.42439	−0.42854	−0.12273	−0.11742
λ		0.47341***		0.6544***		0.3876***
R^2	0.25	0.24	0.37	0.38	0.14	0.14
AIC	1111.24	1114.29	1174.16	1173.69	−204.255	−205.99
Moran's I	−0.0416	−0.0250	−0.0179	−0.0203	0.0065	0.0055

* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level. Moran's I was computed with the residuals from each model using the same first-order queen contiguity matrix.

Table 5
Spatial lag regression results for the research question, "does variation in neighborhood environmental conditions predict the resulting stewardship networks in Seattle?" $N = 93$.

Variable	y = OrgCount		y = NumTies		y = Density	
Model type	Lag	Error	Lag	Error	Lag	Error
Wy	0.62525***		−0.03593		0.33703***	
Intercept	5.20694*	3.18731	6.50829	6.19573*	−0.19926	−0.15132
Can_P	−0.00010	0.04497*	−0.04313	−0.05059*	−0.00073	−0.00077
Grass_P	−0.01498	0.09463*	−0.26583	−0.06344	0.00062	0.00142
Water_P	−0.95253	−0.06645	−0.10075	−0.11591	−0.00398	−0.00331
PopD	−0.00007	−0.00007	−0.00003	−0.00002	−0.00000	0
P_White	3.00447	3.91455	2.89593	2.141	−0.11355	−0.07903
P_OwnerOcc	0.94227	−1.88067	6.74411*	7.65294**	0.21911	0.27357
P_Edu	−5.06406	−0.39459	−5.94755	−4.98033	0.46077	0.39926
P_HighInc	−1.49969	−1.79999	−4.21251	−4.33661	−0.34121	−0.38408
λ		0.74683***		−0.25296		0.34967***
R^2	0.41	0.45	0.10	0.13	0.16	0.16
AIC	426.634	423.21	471.827	468.174	−110.408	−112.031
Moran's I	−0.0382	−0.0195	−0.0602	−0.0014	0.0011	0.0069

* Significant at 10% level.
** Significant at 5% level.
*** Significant at 1% level. Moran's I was computed with the residuals from each model using the same first-order queen contiguity matrix.

Table 6
Spatial lag regression results for the research question, "does the presence of stewardship organizations or networks affect neighborhood tree canopy cover in Baltimore or Seattle?".

Variable	Baltimore ($N = 271$)		Seattle ($N = 93$)	
	Coefficient (y = Can_P)		Coefficient (y = Can_P)	
	Lag	Error	Lag	Error
Wy	0.71179		0.45132	
Intercept	8.79945***	28.74088***	−26.62594**	−22.17924
OrgCount	1.15789***	1.03530***	0.50217	1.27748**
NumTies	−0.91357***	−0.78667**	−0.67110	−0.73014
Density	1.26200	1.36345	4.67307	2.28694
PopD	−0.00042***	−0.00032***	0.00042	0.00048
P_White	−2.46810	6.83940**	−14.84231	−18.50291
P_OwnerOcc	−4.98117	−9.11545**	28.65027***	34.73647***
P_Edu	1.42457	−8.05761**	32.70111	35.93352
P_HighInc	19.31069***	22.78356***	8.14706	6.92129
λ		0.81057***		0.56586***
R^2	0.69	0.71	0.58	0.58
AIC	2016.03	2012.88	689.096	690.129
Moran's I	−0.0372	−0.0574	0.0215	0.0061

** Significant at 5% level.
*** Significant at 1% level. Moran's I was computed with the residuals from each model using the same first-order queen contiguity matrix.

In the first set of regression analyses, none of the land cover categories – water, trees, or other vegetation – were found to be good predictors of the number of stewardship organizations, the ties between them, or the density of those ties in Baltimore neighborhoods. In Seattle, the error model for organization count showed that increased vegetation (trees and grass/shrub) correlated with increases in the number of stewardship organizations in a neighborhood, providing some evidence that the existence of these resources may lead to the establishment of organizations to steward them. However, there was no sound evidence that land cover variables correlated with either network variable. This suggests that the presence of natural resources alone does not lead to network formation. The drivers may be more complex, or there may be different drivers at work. Including additional independent variables such as the quantity of or distance to open space or protected areas could be included in future studies.

Given the strong social, political, economic, and environmental complexity of urban environmental stewardship, the question "what causes urban stewardship networks to form?" was not explored in this study. But through the unique combination of social network and spatial analyses, we observed that in Baltimore higher incomes and more organizations co-occur in neighborhoods with more abundant tree canopy. Conversely, neighborhoods with a greater number of ties between organizations and higher population densities have less canopy cover. In Seattle, home ownership alone seems most important in explaining the variation in urban tree canopy. Previous studies in Baltimore have demonstrated that canopy varies quadratically with time (Troy et al., 2007), and historic demographic characteristics may provide superior explanations to present-day spatial variation of canopy coverage (Boone et al., 2009). Thus, the relationships between former built environmental or social characteristics may also be important in understanding social networks and their formation, and could be included in subsequent research. Another future direction would be to conduct focused interviews with key organizations to better understand how and why they formed relationships with each other. A similar line of inquiry was pursued in New York City to explore the most connected organizations (Connolly et al., 2013). Qualitative, intensive, and process focused data collection techniques are complementary and mutually reinforcing to the quantitative, extensive, and pattern detection oriented methods used here (Grove, Pickett, Whitmer, & Cadenasso, 2013). Interviews with groups would help explain the causes of the patterns observed, and add a layer of context to this study while prompting further questions for empirical research.

Finally, we intend for this study to establish a foundation for the longitudinal analysis of urban environmental stewardship networks. By collecting both network and land cover data over time, future analyses will be able to examine how changes in structure relate to changes in the local environment.

SUGGESTION 2: Conduct analyses of specific neighborhoods and/or sub-networks.

In the second set of regression analyses, the results failed to reject the null hypothesis in Seattle. However, Baltimore results demonstrated significant relationships among organizational and network variables and tree canopy. As hypothesized, the number of stewardship organizations was positively related to tree canopy, with the presence of each stewardship organization corresponding to 1.16% more tree canopy. Preliminary unpublished results of New York City stewardship research support these trends. In a study of changes in vegetation and stewardship, researchers found that while most NYC neighborhoods lost vegetation from 2000 to 2010, those that gained tended to have six stewardship groups whereas those neighborhoods that lost vegetation tended to have only two groups conducting stewardship activities. Baltimore results also showed a significant relationship between the number of ties among stewardship organizations and percent tree canopy, yet not as hypothesized. The number of ties was negatively related to tree canopy; there was nearly 1% less tree canopy with every additional tie between organizations.

We hypothesize that these two, seemingly contradictory findings suggest that there might be two types of stewardship groups. One type of stewardship group might focus on conservation of existing trees in areas with higher levels of canopy cover. Another type of group might concentrate on rehabilitation by planting new trees in areas with low levels of existing cover. Conservation is more associated with maintenance of the existing resource: pruning, mulching, and watering, for instance. Rehabilitation is more resource intensive, including materials such as trees, soils, stakes, and mulch; human and machine labor; and coordination of permissions and permits in order to work on diverse lands such as vacant lots, public-rights-of-way, and school yards. There may be fewer groups with the capacity, but working in collaboration (more ties) in re-vegetation areas (low canopy). Further, it can take a number of years before trees grow large enough to be measured using existing tree canopy mapping tools. The data from the survey do not permit us to test this hypothesis because of the ways Questions 3 and 10 were collected (Appendix 1). Currently, we ask respondents to identify a complete lists of stewardship activities they perform (Q3) and places where they work (Q10). However, we cannot determine from these data which particular activities an organization performs in a particular place. This is an issue because many organizations engage in more than one activity and work in more than one place. For instance, 149 Baltimore organizations (89%) reported that they care for a place in the local environment, and 145 Baltimore organizations (86%) reported engaging in conservation activities. Thus, an organization might have conservation activities in one neighborhood and restoration activities in another neighborhood, but the specific relationship between a stewardship activity and a geographic place cannot be determined from our survey. Follow-up surveys with stewardship groups to map their specific conservation and rehabilitation activities in neighborhoods with high and low levels of tree canopy cover are needed to examine this hypothesis.

The results were mixed when considering trends across cities. As discussed, land cover was not a good predictor of stewardship organizational presence or relationships in either city's results. Yet the one significant relationship found only in Baltimore may be a cause for further examination. All of the network variables were found to be positively related to neighborhoods that are predominantly White. This finding is a potential environmental and social justice issue worth further exploration. For instance, predominantly White neighborhoods might have higher levels of canopy cover and a focus on conservation, which would lead to higher densities of stewardship groups. There may also be a longer history of community- and city-level organizing around environmental issues in predominantly White neighborhoods, which could lead to increased numbers of ties. Future work could target specific neighborhoods for in-depth follow-up research.

SUGGESTION 3: Employ new approaches to spatial analysis.

We encountered certain limitations in our study that we see as an opportunity for further methodological development. We used the given neighborhood boundaries identified by the planning departments in each city, as it was expected organizations would be familiar with the commonly accepted neighborhood names and boundaries and that this would produce more accurate responses. In some cases, these locally defined neighborhoods conformed perfectly to Census block groups, yet in others, they did not. This required disaggregating each variable into the ratios that fit into the neighborhood boundaries, and then re-aggregating the combination of values to fit the neighborhood boundaries. This may have created a less precise socio-demographic representation of neighborhood conditions than aggregating from smaller

units. In addition, Baltimore has almost three times the number of neighborhoods as Seattle, even though the land area of the two cities only differs by a few square miles (Fig. 2). The smaller size of Baltimore's neighborhoods leads to a more homogenous representation of networks and land cover features within each neighborhood when compared to the larger and therefore more heterogeneous internal nature of Seattle's neighborhoods. Because there are fewer neighborhoods in Seattle, collinearity among predicting variables was greater. Also compounding this issue, the underlying land cover data sets had different accuracies, which may be considered a limitation.

Thus, future research could examine stewardship activities at more standardized geographic areas, such as the Census block group, or even an artificially imposed grid based on where stewardship activities specifically take place. Alternatively, data analysis at a finer scale could parse apart, for example, the differences associated with stewardship on public versus private land. Digitization of groups' self-defined stewardship turfs has been completed for other cities in this stewardship research program. These written descriptions provide more precise geographical representation of stewardship activities and this enhanced set of stewardship boundaries may improve the spatial analyses. Finally, an updated land cover assessment is anticipated to be performed in Seattle. Increased accuracy of the land cover data will contribute to more accurate interpretations and conclusions.

5. Conclusion

The results from this research suggest the need for further methodological and theoretical advances. In terms of methods, for instance, there was no support for a relationship among stewardship networks and tree canopy in Seattle. This may be attributable to the small number of neighborhoods used for Seattle, which may have produced a relatively high level of social–ecological heterogeneity within each neighborhood and confounded our spatial analyses. In Baltimore, the number of stewardship organizations was positively related to tree canopy, and the number of ties between organizations was negatively related to tree canopy. In terms of theory development and testing, these results suggest that differing network structures may be required for conservation and re-vegetation. Finally, collecting both spatially explicit stewardship network and land cover data over time will allow for the causes and consequences to be better understood, representing an exciting opportunity for advancing both theory and methods.

While in-depth case studies of collaborative, networked natural resource management exist, there have been few empirical studies examining large, citywide datasets to assess the distribution and environmental outcomes of organizations and networks across geographic space. This work advances urban environmental stewardship research by exploring the spatial dimensions of stewardship networks in association with environmental features and demographic characteristics at the neighborhood level. Further, commonalities and differences in socio-spatial stewardship networks were examined by comparing two similar cities. This comparison suggests the potential relevance and importance of a multi-city research agenda comparing urban areas of similar and different sizes and social, cultural, and environmental histories in order to more fully characterize urban governance systems.

Acknowledgments

This article was adapted from a chapter of Dr. Romolini's dissertation from the University of Vermont, and thus we thank her committee members—Christopher Koliba, Daniel Krymkowksi, and Curtis Ventriss—for substantial contributions in the development of the research. We are grateful to all of the organizations in Baltimore and Seattle who participated in our survey, and particularly to those who offered valuable input along the way. The research would not have been possible without generous contributions of spatial data from the University of Vermont's Spatial Analysis Laboratory and the University of Washington's Remote Sensing and Geospatial Applications Laboratory; material and intellectual support from the USDA Forest Service's Pacific Northwest and Northern Research stations; and financial support of ARRA Project 10-CA-11260489-090, NSF-DEB-0423476, and DC-BC ULTRA-Ex NSF-DEB-0948947. Any opinions, findings, and conclusions or recommendations expressed in this manuscript are those of the authors and do not necessarily reflect the views of any of the contributors.

Appendix A. Organizational Survey Instrument (Seattle)

SEATTLE AREA STEWARDSHIP MAPPING AND ASSESSMENT PROJECT

Does your organization work on behalf of the environment in some way? This may include planting trees, advocating against toxics, restoring a riparian area, gardening in a schoolyard, or some other stewardship activity. We would like to learn about these activities, including what your organization does, where, and why.

The intent of this study is to understand environmental stewardship in the Seattle region. We define stewardship as conserving, managing, caring for, monitoring, advocating for, and educating the public about local environments.

A similar study was conducted in New York City, and it has helped stewardship groups connect with each other, obtain new resources and partners, and has helped support citizens as they work on behalf of their local environment.

This survey should take about 20-30 minutes to complete. Based on the information we collect, we will develop maps to show where and how people work together to improve the environment of the region. Thanks in advance for completing the survey; your input will help us to develop a complete picture of stewardship in the Seattle area.

1. Please enter your contact information to get started.

Your personal information is confidential. We will not share your name, personal email, personal phone number, or other identifying information with anyone outside of the research team. We may contact you if we have questions about information you provide on this survey.

Your name:

Your title or position description:

Your phone number:

Your email:

From this point on you will be asked a series of questions about your group or organization. Please try to provide responses that indicate the conditions or situations of the entire organization or group, rather than just your own personal experience or preferences.

2. Basic Information about your group/organization.

Group/organization name:

Web site (if available):

Mailing Address (with City, State, ZIP):

Group/organization Email:

Group/organization Phone:

Does your group/organization wish to be listed in a public, online stewardship database? In other cities, this database allows stewards who share interests to find each other and collaborate if they wish. YES/NO

3. Please tell us about your group/organization's environmental stewardship activities:

How often does your organization do the following types of stewardship activities?	Never	Sometimes	Often
Conserve the local environment?			
Take care of a place in the local environment (for example, a community garden, a block of street trees, an empty lot, a riverbank, a schoolyard, a forest preserve)?			
Restore or transform local ecosystem (for example, daylighting a stream, brownfield recovery, or habitat restoration)			
Monitor the quality of the local environment? (for example, monitoring air or water quality, or species monitoring)?			
Advocate for the local environment?			
Educate the public about the local environment?			

**Skip logic: If anyone answers "never" to all questions, jump to a page that says:*

"Thank you for your interest in filling out this survey. Based on your response to the last question, your group/organization's activities do not fit into our research definition.

If you made a mistake while filling out the last question(s), please click the Back arrow (below) to update your response."

Please tell us about your group/organization:

4. What is your group/organization's legal designation? (Please choose the most appropriate response).

501(c)(3) (or has applied)

501 (c)(4) (or has applied)

Community group/organization without 501(c)(3) or 501(c)(4) status (such as a block club)

School district

Federal government agency

State government agency

Local government agency

Public institution (not an agency)

Quasi governmental (such as a port authority)

Private firm, for-profit business → *If checked, then pop-up with a note that says, "For this survey, please answer stewardship questions based only on the stewardship work that your business does that is volunteer or pro bono."*

Other (please specify) _____

5. Tell us about what your group/organization does:

Below is a list of possible purposes and functions of organizations. How well does each of the following describe the purpose or function of your group or organization?	not at all	somewhat	very well
Public health (including mental health, food, crisis intervention, health care)			
Education			
Housing and shelter			
Community improvement and capacity building			
Environment (including gardening, forestry, ecological restoration, water and air protection)			
Toxics/pollution related			
Animal related			
Human services (including day care, family services)			
Youth development			
Economic or business development			
Employment, job related			
Legal services, civil rights			
Arts, culture, creative practices			
Recreation and sports (including birding and fishing)			
Crime, criminal justice			
International, foreign affairs, and national security			
Research in science and/or technology			
Faith-based activities			
Power/electricity generation			
Energy Efficiency			
Other _____			

6. Considering all of the programs, activities, and services your group/organization does, what percentage of your effort is for stewardship?

0 – 19%	20 – 39%	40 – 59%	60 – 79%	80 – 100%

7. Below are possible project sites/settings for stewardship. In the past year, how often did your group or organization do stewardship work at each of the site types?	never	sometimes	often
WATER & WATER-RELATED			
Watershed / Sewershed			
Stream / River / Canal			
Waterfront / Beach / Shoreline			
Wetland			
OPEN SPACES & NATURAL AREAS			
Prairie/Savanna			
Forest/Woodland			
Park			
Community garden			
Urban farm			
Playing field / Ball field			
Dog run or dog park			
Public garden (botanical garden, arboretum, etc.)			
Trails / Bike paths / Greenway / Rail-trail			
NATURE IN BUILT PLACES			
Residential building grounds (apartment courtyard, back yard, etc.)			
Vacant Land / Vacant Lot			
Brownfield property			
School yard or grounds / Outdoor classroom			
Grounds of public building other than school (city hall, library, hospital, etc.)			
Courtyard / Atrium / Plaza			
Street trees / Boulevard/ traffic island / greenstreet / parkway (Public right of way)			
Rain gardens / rain barrels / permeable pavement / bioswales			
Green buildings			
Green roofs			
Flower box / Planter			
Other _____			

8. Please tell us why your group/organization does stewardship work. [Freeform answer.]

Please tell us where your group/organization physically conducts stewardship activities:

9. What is the broadest geographic scope of your group or organization's stewardship activities?

International
National
Multiple states
State of Washington
Regional (e.g. several neighboring counties, a landscape element such as the Puget Sound, etc.)
County
City of Seattle
Local (e.g. one or more neighborhoods, specific greenspaces within the city, etc.)

10. Please identify all Seattle neighborhoods in which you work. Click on the neighborhood name for a map. If you are still unsure, please visit the City Clerk's website for additional maps: http://clerk.ci.seattle.wa.us/~public/nmaps/neiglist.htm.

[LIST OF NEIGHBORHOODS HYPERLINKED TO CITY CLERK'S NEIGHBORHOOD MAPS]

11. Please describe in detail the boundaries of where your group/organization has done work in the last year. Be as specific as possible. You can list multiple locations.

For example:
"Interlaken Park" – "All of King County" – "the traffic circle on Belmont and E Thomas" – "The Puget Sound" – "along the Duwamish River" – "the Bradner Gardens P-Patch"

12. Approximately what year was your group/organization founded? _____

Note: for national or regional groups/organizations please tell us the approximate year your chapter was founded.

13. Approximately how many of the following does your group/organization have:

Full-time staff: _____
Part-time staff: _____
Members: _____
Regular Volunteers: _____ (note regular volunteers are those who routinely volunteer in your group/organization's activities. This is different from volunteers who may come out for a single work day).

For those volunteers who come out occasionally, can you estimate how many hours they contribute? per . . . . week _____ or month _____ or year _____

14. How often does your group/organization use the following methods to share information with the public?	never	sometimes	often
N/A, we don't share information			
National media			
Local media			
Direct mailing / newsletters			
Door-to-door outreach			
Flyers / signs			
Website			
Listserv			
Social media (e.g. blog, Facebook, Twitter)			
National conferences/meetings			
Regional conferences/meetings			
City conferences/meetings			
Neighborhood-based conferences/meetings			
Radio			
TV			
Other (please specify) _____			

15. What is your group/organization's estimated annual budget for the current year?

_____

Check box: Prefer not to answer ☐

16. Please indicate the level of funding your group/organization has received in the last year from the following sources.	no funding	minor funding	major funding
Corporate giving/sponsorship			
Local foundation			
National foundation			
Endowment			
Fees/program Income			
Fundraisers (events, dinners, etc.)			
Individual donations			
Memberships			
Federal government			
State government			
Municipal government			
Other (Please Specify) _____			

GROUP/ORGANIZATIONAL RELATIONSHIPS

In the final section of the survey, please tell us about your group or organization's relationship to other groups and organizations.

For all questions in this section, we are interested in hearing about all possible collaborations. These may include federal, state, and local government; private companies; nonprofits, schools, or community group/organizations; etc.

17. In the past year, did you seek information, advice, or expertise from other groups or organizations?

Please list up to ten groups/organizations from whom you received information, advice, or expertise related to environmental stewardship:

18. In the past year, did you offer information, advice, or expertise to other groups or organizations?

Please list up to ten group/organizations to whom you provided information, advice, or expertise related to environmental stewardship in the past year:

19. Please list up to ten group/organizations from whom you received funding related to environmental stewardship in the past year:

20. Please list up to ten group/organizations to whom you provided funding related to environmental stewardship in the past year:

21. Does your group/organization belong to any coalitions, partnerships, or working groups to share information, plan strategy, or coordinate activities? Yes/No

If yes, please list the coalition(s) your group/organization is active in.

22. Is there anything else you would like to tell us about your group/organization or this survey?

This concludes the Seattle stewardship assessment. Thank you for your participation. We will send you an announcement when our report and stewardship maps are available.

Feel free to contact us with any questions or comments at: stewards@u.washington.edu

References

Akaike, H. (1978). On the likelihood of a time series model. *Statistician*, *27*, 217–235.

Anselin, L., Syabri, I., & Kho, Y. (2006). GeoDa: An introduction to spatial data analysis. *Geographical Analysis*, *38*(1), 5–22.

Belaire, J. A., Drilbin, A. K., Johnston, D. P., Lynch, D. J., & Minor, E. S. (2011). Mapping stewardship networks in urban ecosystems. *Conservation Letters*, *4*, 464–473. http://dx.doi.org/10.1111/j.1755-263X.2011.00200.x

Bodin, O., Crona, B., & Ernstson, H. (2006). Social networks in natural resource management—What's there to learn from a structural perspective? *Ecology and Society*, *11*(2), r2. Retrieved from ⟨http://www.ecologyandsociety.org/vol11/iss2/resp2⟩

Bodin, Ö., & Crona, B. I. (2009). The role of social networks in natural resource governance: What relational patterns make a difference? *Global Environmental Change*, *19*, 366–374.

Boone, C. G., Cadenasso, M. L., Grove, J. M., Schwarz, K., & Buckley, G. L. (2009). Landscape, vegetation characteristics, and group identity in an urban and suburban watershed: Why the 60s matter. *Urban Ecosystems*, *13*(3), 255–271. http://dx.doi.org/10.1007/s11252-009-0118-7

Borgatti, S. P., Everett, M. G., & Freeman, L. C. (2002). *Ucinet for windows: software for social network analysis*. Harvard, MA: Analytic Technologies.

Burch, W. R., & DeLuca, D. R. (1984). *Measuring the impact of natural resource policies*. Albuquerque, NM: New Mexico University Press.

Connolly, J. J., Svendsen, E. S., Fisher, D. R., & Campbell, L. K. (2013). Organizing urban ecosystem services through environmental stewardship governance in New York City. *Landscape and Urban Planning*, *109*, 76–84. http://dx.doi.org/10.1016/j.landurbplan.2012.07.001

Crona, B., & Bodin, Ö. (2006). What you know is who you know? Communication patterns among resource users as a prerequisite for co-management. *Ecology and Society*, *11*(2), 7.

Ernstson, H., Barthel, S., Andersson, E., & Borgström, S. T. (2010). Scale-crossing brokers and network governance of urban ecosystem services: The case of Stockholm. *Ecology and Society*, *15*(4), 28.

Ernstson, H., Sorlin, S., & Elmqvist, T. (2008). Social movements and ecosystem services—The role of social network structure in protecting and managing urban green areas in Stockholm. *Ecology and Society*, *13*(39), 1–27.

Fisher, D. R., Campbell, L. K., & Svendsen, E. S. (2012). The organisational structure of urban environmental stewardship. *Environmental Politics*, *January*, 37–41. http://dx.doi.org/10.1080/09644016.2011.643367

Grove, J. M., & Burch, W. R. (1997). A social ecology approach to urban ecosystem and landscape analyses. *Urban Ecosystems*, *1*, 259–275.

Grove, J. M., Pickett, S. T. A., Whitmer, A., & Cadenasso, M. L. (2013). Building an urban LTSER: the case of the Baltimore ecosystem study and the D.C./B.C. ULTRA-Ex Project. In S. J. Singh, H. Haberl, M. Chertow, M. Mirtl, & M. Schmid (Eds.), *Long term socio-ecological research* (pp. 369–408). Dordrecht: Springer Netherlands. http://dx.doi.org/10.1007/978-94-007-1177-8

Grove, J. M., Troy, A. R., O'Neil-Dunne, J. P. M., Burch, W. R., Cadenasso, M. L., & Pickett, S. T. A. (2006). Characterization of households and its implications for the vegetation of urban ecosystems. *Ecosystems*, *9*(4), 578–597. http://dx.doi.org/10.1007/s10021-006-0116-z

Land Cover, Baltimore, MD. (2007). Raster dataset. In *Spatial analysis laboratory at the University of Vermont, Burlington, VT.* , 2009.

Land Use/Land Cover, Seattle, WA. (2009). Raster dataset. In *Moskal's remote sensing and geospatial applications laboratory (RSGAL) precision forestry cooperative*. Seattle, WA: School of Forest Resources, University of Washington.

Lauber, T. B., Decker, D. J., & Knuth, B. A. (2008). Social networks and community-based natural resource management. *Environmental Management*, *42*, 677–687.

Landry, S. M., & Chakraborty, J. (2009). Street trees and equity: Evaluating the spatial distribution of an urban amenity. *Environment and Planning A*, *41*(11), 2651–2670. http://dx.doi.org/10.1068/a41236

Laven, D. N., Krymkowski, D. H., Ventriss, C. L., Manning, R. E., & Mitchell, N. J. (2010). From partnerships to networks: New approaches for measuring U.S. National Heritage Area effectiveness. *American Evaluation Review*, *34*(4), 271–298. http://dx.doi.org/10.1177/0193841

Machlis, G. E., Force, J. E., & Burch, W. R., Jr. (1997). The human ecosystem. Part I: The human ecosystem as an organizing concept in ecosystem management. *Society and Natural Resources*, *10*, 347–367.

Mandarano, L. A. (2009). Social network analysis of social capital in collaborative planning. *Society & Natural Resources*, *22*(3), 245–260. http://dx.doi.org/10.1080/08941920801922182

Moran, P. A. P. (1948). The interpretation of statistical maps. *Journal of the Royal Statistical Society Series B*, *10*, 243–251.

Moskal, L. M., Styers, D. M., & Halabisky, M. (2011). Monitoring urban forest canopies using object-based image analysis and public domain remotely sensed data. *Remote Sensing Special Issue on Urban Remote Sensing*, *3*(10), 2243–2262. http://dx.doi.org/10.3390/rs3102243

Muñoz-Erickson, T. A., Cutts, B. B., Larson, E. K., Darby, K. J., Nef, M., Wutich, A., & Bolin, B. (2010). Spanning boundaries in an Arizona watershed partnership: Information networks as tools for entrenchment or ties for collaboration? *Ecology and Society*, *15*(3), 1–22.

O'Neil-Dunne, J. P. M. (2009). *A report on the city of Baltimore's existing and possible tree canopy*. Burlington, VT, Spatial Analysis Lab, Rubenstein School of the Environment and Natural Resources, University of Vermont. Retrieved from ⟨http://www.fs.fed.us/nrs/utc/reports/UTC_Report_BACI_2007.pdf⟩

Pham, T., Apparicio, P., Séguin, A., Landry, S., & Gagnon, M. (2012). Spatial distribution of vegetation in Montreal: An uneven distribution or environmental inequity? *Landscape and Urban Planning*, *107*(3), 214–224. http://dx.doi.org/10.1016/j.landurbplan.2012.06.002

Prell, C., Hubacek, K., & Reed, M. (2009). Stakeholder analysis and social network analysis in natural resource management. *Society & Natural Resources*, *22*(6), 501–518. http://dx.doi.org/10.1080/08941920802199202

Provan, K. G., & Milward, H. B. (2001). Do networks really work? A framework for evaluating public-sector organizational networks. *Public Administration Review*, *61*(4), 414–423. http://dx.doi.org/10.1111/0033-3352.00045

Raddatz, L., & Mennis, J. (2012). Environmental justice in Hamburg, Germany. *The Professional Geographer*, *64*(2), 18. http://dx.doi.org/10.1080/00330124.2012.700500

Romolini, M. (2013). Governance of 21st century sustainable cities: Examining stewardship networks in Baltimore & Seattle. In *Unpublished doctoral dissertation*. Burlington, VT: University of Vermont.

Romolini, M., Brinkley, W., & Wolf, K. L. (2012). *What is urban environmental stewardship? Constructing a practitioner-derived framework. Research note PNW-RN-566*. Seattle, WA: Pacific Northwest Research Station, U.S. Department of Agriculture, Forest Service. Retrieved from ⟨http://www.naturewithin.info/CivicEco/pnw_rn566_USFS_3CM_Rsrch_Note.pdf⟩

Sampson, R. J., Morenoff, J. D., & Gannon-Rowley, T. (2002). Assessing "neighborhood effects": Social processes and new directions in research. *Annual Review of Sociology*, *28*, 443–478. http://dx.doi.org/10.1146/annurev.soc.28.110601.141114

Sandström, A. (2008). Policy networks: The relation between structure and performance. In *Doctoral dissertation*. Luleå, Sweden: Department of Business Administration and Social Sciences, Luleå University of Technology.

Schneider, M., Scholz, J., Lubell, M., Mindruta, D., & Edwardsen, M. (2003). Building consensual institutions: Networks and the National Estuary Program. *American Journal of Political Science*, *47*(1), 143–158. http://dx.doi.org/10.1111/1540-5907.00010

Seto, K. C., Sánchez-Rodríguez, R., & Fragkias, M. (2010). The new geography of contemporary urbanization and the environment. *Annual Review of Environment and Resources*, *35*(1), 167–194. http://dx.doi.org/10.1146/annurev-environ-100809-125336

Svendsen, E. (2010). Civic environmental stewardship as a form of governance in New York City. In *Unpublished doctoral dissertation*. New York: Columbia University.

Svendsen, E. S., & Campbell, L. K. (2008). Urban ecological stewardship: Understanding the structure, function and management. *Cities and the Environment (CATE)*, *1*(1), 1–32.

Troy, A. R., Grove, J. M., O'Neil-Dunne, J. P. M., Pickett, S. T. A., & Cadenasso, M. L. (2007). Predicting opportunities for greening and patterns of vegetation on private urban lands. *Environmental Management*, *40*(3), 394–412. http://dx.doi.org/10.1007/s00267-006-0112-2

United Nations. (2012). *World urbanization prospects: The 2011 revision*. New York: Population Division, Department of Economic and Social Affairs, United Nations. Retrieved March 21, 2013 from ⟨http://esa.un.org/unup/unup/p2k0data.asp⟩

Ward, M. D., & Gleditsch, K. (2008). *Spatial regression models*. London: Sage.
Wolf, K. L., Blahna, D., Brinkley, W., & Romolini, M. (2013). Environmental stewardship footprint research: Linking human agency and ecosystem health in the Puget Sound region. *Urban Ecosystems*, *16*, 13–32.
Zhou, W., Troy, A. R., Grove, J. M., & Jenkins, J. C. (2009). Can money buy green? Demographic and socioeconomic predictors of lawn-care expenditures and lawn greenness in urban residential areas. *Society & Natural Resources*, *22*(8), 744–760. http://dx.doi.org/10.1080/08941920802074330