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Environmental stewardship footprint research: linking human agency and ecosystem health in the Puget Sound region

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Abstract Urbanization processes challenge ecosystem health in many metropolitan areas. New policy and program approaches are needed to restore and sustain natural systems as public agencies and organizations face greater demands and declining budgets. Environmental stewardship is an often overlooked intervention strategy, and the full potential of civic engagement by citizens on behalf of ecosystem health is little understood. Using a coupled systems approach, integrated analysis of social and ecological footprints can lead to greater theoretical understanding and more effective programs at the landscape scale. Here we outline two pilot studies as part of an emergent research program that is investigating the extent and impact of environmental stewardship. Qualitative interviews of stewardship managers revealed multiple dimensions of motivations and purposes for stewardship, ranging from the practical to the conceptual. A regional organization census yielded a surprisingly large number of organizations that conduct stewardship, with social and ecological values being of comparable emphasis. The initial research is based in the Puget Sound area of Washington State, U.S., but results have relevance to other urban areas. Pilot study findings now guide additional research effort about motivations, organizational networks, and theory of integrated socio-ecological systems to be derived from comprehensive footprint analysis of stewardship activity.

Keywords Urban ecology · Civic ecology · Puget Sound · Environmental stewardship · Social networks

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Natural systems across the entire urban-wildland landscape gradient confront ongoing threats such as development sprawl, air and water pollution, and climate change. Science and policy entities are responding to threats with initiatives for knowledge building and action. Yet fiscal shortfalls in local government and environmental resource organizations limit capacity to address ecosystem needs and recovery. In the face of limited and declining fiscal and technical resources for ecosystem management, society must consider new solutions to restore and sustain natural systems across the landscape gradient. Better understanding of the relationship between people, human systems, and the natural environment is necessary (Pickett et al. 2001; Marzluff et al. 2008; Wolf and Kruger 2010).

Engagement of human systems, from individual to organizational, is essential. Environmental stewardship (ES) is an acknowledged, though little understood, societal response to the decline of natural systems in built environments. A coupled human and natural systems research approach can help us to better understand how human agency can aid ecosystem recovery and health. Most ecological research addresses anthropogenic effects as inherently negative, with associated implicit messages that the public is largely uncaring or even intentionally destructive. A contrasting perspective is that people can interact with landscapes for mutual benefit. For example, recent theoretical developments by Ostrom and colleagues (2009) point to the capacity of collaborative social groups to effectively manage common pool resources. While most common pool case studies are of more rural areas, the importance of human agency in ecosystem management translates to urban contexts as well. The influence of people and human systems must be treated as more than an exogenous disturbance factor. Better understanding of human action, present and potential, is a critical aspect of socio-ecological systems research (Berkes et al. 2003).

New research program

The Green Cities Research Alliance (GCRA) was launched in 2009 by the Pacific Northwest Research Station of the USDA Forest Service. The purpose of the initiative is to facilitate natural resource research within urban areas of the Pacific Northwest region of the U.S., to coordinate science and community partners within the PNW region, and then, to link investigations to other U.S. regions. This paper describes an emerging research program in Seattle, including start up activities and pilot data collection and analysis. We are simultaneously grounding the research development with ongoing literature review and direct analysis of the stewardship community. A balance of deductive and inductive explorations will move the research team to activity that expands understanding, but also address practical realities.

The earliest effort to assess research priorities included 22 meetings with regional state, municipal, and federal agencies, conservation non-profits, and research organizations in the Pacific Northwest. The role of landscape and environmental stewardship in urban ecosystem health and recovery emerged as a key theme during the meetings. Other formative themes included: 1) providing a vision for urban sustainability; 2) integrating biophysical and social sciences; 3) conducting practical, outcome-based research; 4) conducting science across the landscape gradient from wildland to urban contexts; and 5) conducting collaborative research about complex socio-ecological processes.

The initial science team then focused on interests in social science and resource management, including the dynamics of human systems ranging in scale from institutional to grass-roots activity. Looking across our home agency, the USDA Forest Service, we engaged with colleagues in other U.S. regions who had conducted similar work, particularly

in Chicago, Baltimore, and New York. Theory and practices from these outreach efforts were integrated into Seattle's emergent research program, as were commitments to future cross-city collaborations.

The last step was an exploratory literature review and pilot data collection, both of which are reported in the remainder of this paper.

These efforts culminated in a GCRA research program that focuses on the positive 'ecological footprint' of citizen and organization based environmental stewardship efforts. The ecological footprint concept is a popular expression of urbanization demands and ecosystem impacts (Wackernagel and Rees 1996). However, the footprint metaphor can also be applied to the positive consequences of human action on the landscape to better understand feedbacks between ecological and social benefits of stewardship activities. In the broadest sense this research program will evaluate how well bottom–up stewardship activities contribute to achievement of top–down institutional policy and program objectives for resource conservation (such as estuary recovery and urban forest restoration).

The GCRA regards stewardship not as isolated, occasional actions on the land, but as a set of comprehensive and complex ecosystem responses that are imbedded within coupled human and natural systems. A primary objective is to better understand the pathways and processes by which the ecological and social footprints of stewardship interrelate at the individual, group, and community levels. We seek to build a comprehensive understanding of how ES is conducted, methods for identifying gaps in ES activities, and how ES efforts could be better mobilized to address concerns of urban ecosystem health and sustainability. The GCRA research program will develop and pursue regional scale, long-term studies that integrate across multiple scales of human agency associated with urban natural resources. The research may generate expanded theory concerning urban ecology, and practical results for governmental agencies and other public, private, and nonprofit organizations as they develop, implement, and sustain stewardship programs and activities.

The remainder of the paper presents the literature and conceptual precedents for this research effort, preliminary results of two studies based on a census of existing ES organizations in Seattle and Tacoma, a discussion of the potential implications of ES for the broader Puget Sound basin landscape, and concludes with a discussion of research needs.

Literature and background

Urban ecology studies often conceptualize human systems as externalized sources of disturbance or impact in relationship to changes of biotic systems (e.g. Alberti et al. 2003; Marzluff et al. 2008). Recent analyses have focused on large-scale physical and biological measures (e.g., streams or wildlife habitat), with secondary data or inferences illustrating how human infrastructure and activities (e.g., residential land uses and transportation) impact or inhibit the structure and function of a self regulating "natural system" (Marzluff and Ewing 2008; Paul and Meyer 2008). Environmental outcome metrics and interventions in the form of policies and programs are also often formulated at the macro scale. Human action is thus often reported as an anthropogenic impact, rather than an integral condition or component of ecosystems, let alone a potential *benefit* for ecological health and integrity (Head and Muir 2006).

Scholars from diverse disciplines, from economics and sociology to ecology and earth sciences, call out the importance of explicitly linking human and ecological processes in studying ecological and human well-being (Collins et al. 2000; Grimm et al. 2000; Pickett

et al. 2001; Alberti et al. 2003; Berkes et al. 2003; Gragson and Grove 2006; Kinzig and Cranez 2005; Alberti 2008). Genuine integration of coupled human-natural systems is necessary, as complex, interdependent patterns and processes may not be understood when studied separately by social or natural scientists (Brunckhorst 2002; Liu et al. 2007). Despite recent progress in studying the ecological effects of human activities, the interactions between human processes and ecosystem dynamics in urbanizing ecosystems are still poorly understood.

Place-based stewardship may be a significant factor in urban ecosystem health or recovery (Frumkin 2003). ES efforts are often piecemeal and opportunistic, and tend to be site or project specific, so cumulative effects across individual smaller-scale efforts can be difficult to assess or monitor. Considering temporal effects, while some case study analysis has been done, long term comprehensive monitoring is rare. Thus the consequences of micro-scaled ES activities across communities are not well understood (Carr 2002; Lev 1998), as there has been little research on the effects of stewardship activities on ecosystem protection, recovery, or public awareness at a landscape scale (Svendsen and Campbell 2008; Svendsen 2009). Due to this ES efforts may not be given full credit for their contributions (Hawken 2007), nor adequately included in ecosystem performance outcome measures. While not widely acknowledged by the scientific community as a substantive approach to ecosystem recovery, recent research in New York City suggests that stewardship may be an effective and viable strategy for ecosystem management (Svendsen and Campbell 2008; Andersson et al. 2007), particularly in urbanized areas where citizen action on the land may be more ubiquitous than is recognized.

Definitions and sources

Stewardship is a socio-ecological dynamic that can be initiated for many reasons. Individual decisions to participate are based on diverse extrinsic and intrinsic motivations (Ryan 2006; McPherson 1993; Moskell et al. 2010). Stewardship action may be guided by peer leadership or on recommendation of ecologists and urban planners, but is often compelled by personal connections to a natural resource or system that is in decline, being neglected, or is threatened. Individuals or small groups of people often come together around a common, often urgent environmental cause (Svendsen and Campbell 2008; Wondolleck and Yaffee 2000). Such actions are an expression of human creativity driven by perceptions of need, premised on the deep-seated traditions of volunteerism in America, recognized at least since de Tocqueville (2002) wrote his classic analysis, *Democracy in America*.

Though environmental stewardship may be a vital aspect of a wide variety of activities such as volunteerism, civics, environmentalism through collaboration and partnership, and community-based activity, there is no widely shared definition of the term. An early interpretation by Aldo Leopold in the 1940s is that environmental stewardship represents the commitment of a person to the land, where land has broad, natural, place-based connotations. His definition of a *Land Ethic* and its manifestation through stewardship was one of the early and foundational discussions on the meaning of environmental stewardship (Leopold 1949).

Since then the concept of stewardship has become a wide-ranging notion applied to many contexts and activities. Looking across contemporary writings stewardship is variably defined or described as an ethic, a tool, a result, or a goal. Studies have represented ES as actions, activities, motivations, values, and purposes. Further generalizations include multiple types of actions like volunteerism, civic engagement, and citizen science (Shandas and Messer 2008; Campbell and Wiesen 2009; Moskell et al. 2010). At a large scale, ES may entail the processes of environment-based collaboration and partnership, and at another

level, citizen stewardship may describe a small scale or site level response to perceived issues that are in people's neighborhoods (Svendsen 2009; Moskell et al. 2010). But regardless of scale, ES activities often have extended consequences, and little has been done to synthesize or categorize ES types or components.

There is also a great deal of variability in the organizational and administrative structures that support ES efforts. At one level, entities and programs may be activated by landscape scale policies and associated regulations that are promulgated by community planners, agency officials, and policy decision-makers (Brunckhorst 2002; Berke 2008). Other stewardship groups are composed of citizens organized to address a defined ecosystem condition that has direct personal consequences, acting for change through place-based projects and resources. Some groups are formally self-organized and have 501(c)3 status, some are informal organizations without legal status, and some are membership organizations facilitated by a public entity (Brinkley et al. 2010).

A barrier in defining ES is that assertions about goals are sometimes contradictory. For example, stewardship is often perceived as being associated with property ownership (Svendsen 2009; Kaplan et al. 1998); however, the term may also refer to something that cannot be owned or is strictly communal (Svendsen and Campbell 2008; Hester 2006). Another common contradictory assumption is that stewardship work is meant for the benefit of others; the community as a whole (Svendsen and Campbell 2008) as opposed to efforts for personal benefit (Svendsen 2009; Grese et al. 2000).

Even the outcomes of ES activities are diverse and sometimes at odds. While environmental improvement is often the outcome of concern, ES may be primarily motivated by many other social, economic, and infrastructural purposes. Initial studies of stewardship within urban areas also suggest that environmentally targeted activity may be a primary stated purpose, but that social consequences are substantially important to many organizers and participants (Moskell et al. 2010; Tidball and Krasny 2007; Kuo 2003). Social benefits of stewardship activities are likely to be at least as important as direct or perceived ecological benefits for motivating participation in stewardship. This is reflected in the diversity of types of groups that sponsor ES activities, including faith-based, community improvement, and civil rights groups (Tidball and Krasny 2007; Kuo 2003; Moskell et al. 2010).

Perhaps the only distinct description that we now have about ES is that the activities entail social interactions on behalf of the environment, and the complexity of its forms mirrors the human condition. While the social constructions of the biophysical elements of ecology include readily accepted categories and classifications of natural systems, the perceived variability of human activity may discourage efforts to classify ES. The absence of a detailed typology of ES has led perhaps to its marginalization as a valid restoration strategy. The importance of framing the scope and definition of concepts used is ever more important as new and innovative strategies need to be employed to achieve environmental health (Frumkin 2003). A framework of definition and concept can serve several purposes in a developing research program. First, it can establish a shared vocabulary by which investigators across diverse disciplines can be explicit in describing questions. A framework can be a shared, yet iterative construction that focuses purpose while allowing for the flexibility needed to maintain coherence across a program having myriad research questions (Leshem and Trafford 2007).

Responses, collaborations, and networks

Effects of stewardship have more often been measured in rural landscapes, where stewardship activity is dispersed on the landscape, there is less organizational complexity,

and cumulative effects of multiple organizations are negligible (Hajkowicz and Collins 2009). Citizen participation in associations has been shown to play a role in community management of local natural resources (Weber 2000). Further, a growing body of research examines collaborations between individuals, groups, and organizations to manage local natural resources (Keough and Blahna 2006; Koontz et al. 2004; Ostrom 1990; Wondolleck and Yaffee 2000). On a large scale these complex collaborations can be considered governance systems, which can be responsible for managing an entire region's resources (Andersson and Ostrom 2008; McGinnis 1999).

Based on our start up interviews, the situation in Pacific Northwest (and perhaps all) cities is likely to be different. There may be greater cumulative and synergistic effects due to the multiple programs, organizations, and actions that typically are centered on any urban green space, public or private. Extensive social interactions are revealed in prior human dimensions studies. Active and passive human encounters with city nature generate positive social dynamics in cities (Wolf 2008). These include empowerment (Westphal 2003), place attachment (Grese et al. 2000; Ryan 2006), social ecology (Grove et al. 1999), community resilience (Svendsen 2009; Tidball and Krasny 2007), ecological democracy (Hester 2006), civic engagement (Shandas and Messer 2008), establishing and improving social ties (Kuo 2003), and developing social learning (Wals and van der Leij 2007).

These indirect outcomes have long term and far reaching consequences. Some studies suggest that community based environmental organizations can be used as a proxy to assess local social capital (Kramer 2007; Brunckhorst 2002; Fukuyama 2000). Collaborative resource management can initiate a positive feedback loop, as natural resources collaborations are shown to increase social capital (Mandarano 2009; Wagner and Fernandez-Gimenez 2008; Schneider et al. 2003). In turn, greater social capital can lead to successful management and improvement of natural resources (Kramer 2007; Pretty and Ward 2001) and more resilient social and ecological systems (Berkes et al. 2003; Brunckhorst 2002).

Emerging literature identifies numerous applications of social network analysis (SNA) to understand collaboration in natural resources management. As community based organizations play an ever more important role in managing natural resources, it is likely that successful outcomes are dependent on social capital, and goal-oriented collaborations through organizational networks. Initial efforts have implemented SNA to categorize and understand stakeholder relationships in natural resource management (Prell et al. 2009) and to evaluate social capital in collaborative planning efforts (Mandarano 2009). Other studies describe different types of network structures (Baldassarri and Diani 2007), and scholars suggest that the effectiveness of a network is dependent on its structural condition (Provan and Milward 2001). Absent within the literature is empirical research analyzing network structure as it relates to the organization, administration, and social and environmental outcomes of ES.

Two preliminary studies

Pilot projects were launched to assess the Seattle ES community. Our intent in this data collection was to learn about "civic environmental stewardship," or the volunteer activity of individuals on public property, rather than agency actions or land care conducted on one's personal property. The first pilot was a qualitative investigation of practitioner-based perceptions, the second a census of environmental stewardship organizations. The data help to initially characterize the size and scope of stewardship efforts, and are the precursor to more detailed studies of stewardship motives, activities, and social and environmental

benefits. "Multiple method" or "mixed method" research strategy (Campbell and Fiske 1959; Johnson and Onwuegbuzie 2004) was initiated in the pilot work, and will continue as the research program expands, to achieve convergent validation or "triangulation" (Webb et al. 1966). Due to the extent of partnerships coming together to enable this research, it is anticipated that "participatory action research" (Baum et al. 2006; Minkler et al. 2003) methods will also be employed.

Practitioner perceptions

Multi-method and participatory research methods each assert the value of stakeholder experiences and perceptions. To develop a conceptual framework for stewardship we collected data from the professional stewardship community of practice. Program and project managers have particularly direct experiences of stewardship, yielding understandings that may differ from scientists' observations. We conducted semi-structured qualitative interviews with representatives of nine Seattle environmental organizations, who collectively have over 100 years of experience in the field (Romolini et al. in review). Conceptual Content Cognitive Mapping (3CM) was used to elicit responses to the question "what is environmental stewardship?"

The 3CM method encourages participants to reveal and explore their cognitions and perceptions about a specific idea or activity with which they have in-depth knowledge (Kearney and Bradley 1998; Kearney and Kaplan 1997). Responses are open-ended, rather than constrained by finite lists of questions or variables. Respondents generate words or phrases that are physically arranged in thematic clusters and spatial diagrams. Analysis of 3CM responses generates thematic, structural representations of shared concepts and their interactions across study participants. This approach tapped the rich perceptions and historical knowledge of Seattle stewardship leaders. In addition to guiding questions, the 2-hour interviews included a cognitive mapping task, which allowed the participants to construct a perceptual map of their personal definition of "environmental stewardship."

The seasoned practitioners and program leaders chosen for the task had each been working in the region for at least 15 years, work directly with communities, and collaborate with other organizations to pursue success with on the ground projects. The respondents also represent a cross section of organizational size, geography, and administrative structure. Collectively, they have a multi-layered definition of stewardship, from environmental improvement to community building, from actions to outcomes. This array of perceptions is displayed in their organizational activities, and as further research may show, in organizational networks and outcomes.

In total, the respondents provided 162 words or phrases (described as items in analysis). A sense of passion for one's work emerged across all the interviews. The practitioners spoke of ES as a means to social ends, with terms such as "people" and "community" among the most frequently used (Table 1 includes all words listed more than two times). Volunteerism was called out as an important component in environmental stewardship, illustrated by responses such as "voluntary commitment" and "service to the community." While benefits to the physical environment are often the ostensible basis for an organization's stewardship actions, social and individual benefits and motivators were more commonly mentioned. For example, respondents provided ten permutations of "care" or "caring" (e.g. "caring for place" and "taking action about the things you care about"). Of the 17 most commonly used items, "people" is the third most common, with words such as "volunteer(ism)," "relationships," and "community" also ranking high on the list. Frequencies also indicated that organizations place importance on how people and

Table 1 High frequency words and phrases reported in 3CM interviews

Word or phrase	Count	Word or phrase	Count	Word or phrase	Count
Taking/acting/doing	11	Impact(s)	4	Community	3
Care/caring	10	Volunteer(ism)	4	Service	3
People(s)	7	Place	3	Sustainable	3
Environment(s)	5	Relationships	3	Decisions	3
Space(s)	5	Back	3	Continuum/continue	3
Steward(ship)	5	Part	3		

communities *act*, with action words "taking/acting/doing," "service," and "decisions" having high counts.

Interview participants were then asked to assemble small cards containing the words into clusters, and arrange the clusters by perceptual relationship. Conducting content analysis across all the participants' "maps," several meta-level themes emerged (Table 2). The themes incorporate the organizational and systemic structures constructed by the respondents in the 3CM clustering activity. The seasoned practitioners apparently act based on a wide range of purposes and ambitions: values, desired behaviors and actions, creation of organizational tools, and working toward both environmental and community outcomes. Figure 1 is a spatial characterization of the themes, and begins to suggest a conceptual framework for civic environmental stewardship in Seattle. The schematic diagram, derived from the collective thoughts and actions of long-term and committed practitioners, indicates nodes of motivation and expected outcomes, with process connectors. This interpretive figure is a source of testable questions that can guide future research development.

Respondents conceptualized stewardship at two social scales, the individual and organization. Individual motivations were reported to be value-based, including environmental ethics, personal ethics, and concern for community. Individuals apply their stewardship values through direct behaviors, actions and decisions, as well as the

Table 2 Interpretive themes across respondents' cognitive maps

Values	Behaviors & actions	Organization tools	Desired/realized outcomes
Environment: restoration, reducing impacts	Individual Actions & Decisions: planting, carrying a reuseable mug, picking up trash	Directed Natural Resource Programs: organizing tree plantings, invasive species removal	Environmental Improvement: creating healthy green spaces, sustainable balance of built & natural
Personal Ethics: moral obligation, spirituality, taking action for what we care about	Collective Actions: noticing each others' actions, getting others to help	Outreach, Education, Citizen Engagement: stewardship education, advocacy, diverse activities	Community Building: opening up to neighbors, creating continuum of stewardship behavior, open to others' ideas, cultivating healthy relationships
Concern for Community: camaraderie, taking back communities, (e.g. from crime)		Collaborating with Organizations: cooperative centers, government interaction	

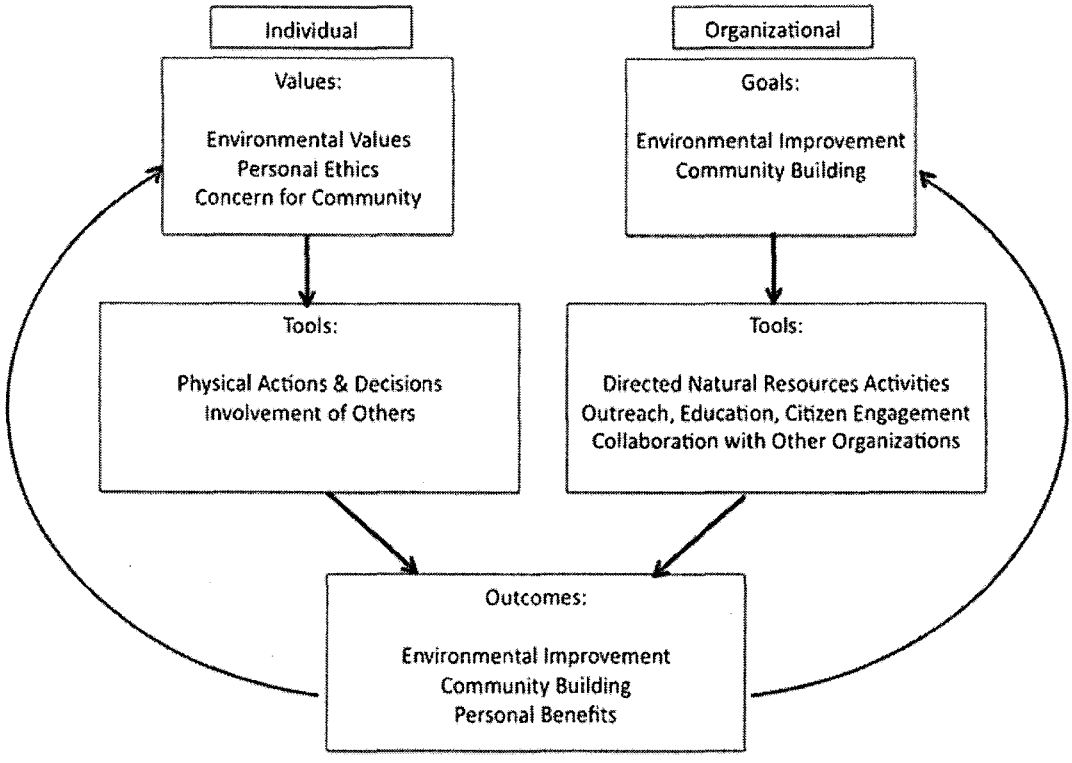

Fig. 1 Schematic diagram of practitioners' stewardship cognitive maps

involvement of others. Action outcomes are perceived to be environmental improvement and community building, as well as personal benefits such as meaning or realization of personal passion. These positive outcomes can strengthen initial motivations.

Organizational stewardship was often represented as goal-based, separated into the broad categories of environmental improvement and community building. To reach their desired outcomes, organizations use multiple approaches, interventions, or tools. These include direct collective programs to improve and protect natural resources; outreach, education, and citizen engagement; and collaboration with other stewardship organizations, often through coalitions or partnerships.

Organization census

A census of public and non-profit organizations that sponsor environmental stewardship was conducted (Brinkley et al. 2010). The preliminary database compilation was completed for organizations operating across a portion of the metropolitan Seattle area (King and Pierce Counties), and was a first step in exploration of the magnitude of the stewardship footprint. Later, full development of records will enable GCRA to: identify and assess organizational resources and needs, coordinate efforts across the region, provide information to program leaders and managers, and initiate collaborative research across other U.S. regions.

The database was populated by a rapid assessment Internet search using a snowball sampling method. An initial set of local organizations and agencies were identified as entities having a prominent public commitment to civic stewardship, which was defined as motivated physical action, education, or outreach for the purpose of improving the physical environment. As organizations were recorded, their web-listed partners, collaborators, and

contacts were then added to the search list. As the list was constructed, information was collected for each organization from websites, including home office address, county, web contact information, type of organization and tax status (non-profit, private, etc.), and mission statement. Data records for project focus included scope (one or multiple sites); type of ecological system (terrestrial or aquatic); and the *location along* the landscape gradient where the organization was active, ranging from urban to wildland settings.

The rapid assessment process identified 588 organizations conducting environmental stewardship in the greater Seattle/Tacoma area (51% exclusively in King County, 16% exclusively in Pierce County, and 33% in both). Descriptive statistics indicate some notable patterns (Brinkley et al. 2010). Most organizations are active in multiple sites, the types of ES organizations are varied, and activity on waterways and water bodies was prevalent. There is surprising diversity of legal status and affiliation within the organizational population (Fig. 2). Non-profits comprise 64% while private, environmentally oriented business interests represented 13% of the tally. This compares to 62% and 1% respectively in New York City (Svendsen and Campbell 2008). Thus there are more for-profit firms or co-op based programs, and fewer public programs in the Seattle region.

Eight percent of the entities are non-profit coalitions (Fig. 2), which are partnerships, alliances, and collaborative organizations. These organizations are the public identity for self-aggregating clusters of smaller organizations that combine efforts on projects, technical resources, policy, or advocacy. For instance, the Green City Partnerships (a program between the Cascade Land Conservancy and cities around the region) aligns with organizations across municipalities to effect common goals and practices for natural areas restoration. These organizational associations may be important for ES efficacy, as they may afford operational efficiencies and collaborative structures for delivering stewardship resources.

Activity location is found throughout urban, suburban, rural, and wildland settings. Of the 453 organizations that had accessible information about gradient location(s), 74% are active in urban areas, 32% have programs in wildlands, with similar mid level rates of activity in suburban and rural areas (56%) (Fig. 3). Forty-three percent of organizations work at locations throughout the landscape gradient, that is, they conduct work in either urban or suburban landscapes *and* rural or wildland areas. Fourteen percent of organizations

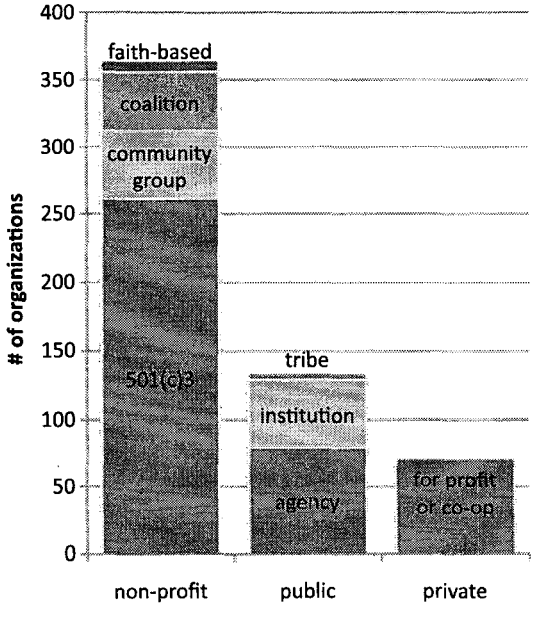

Fig. 2 Organization types and legal status ($n=570$)

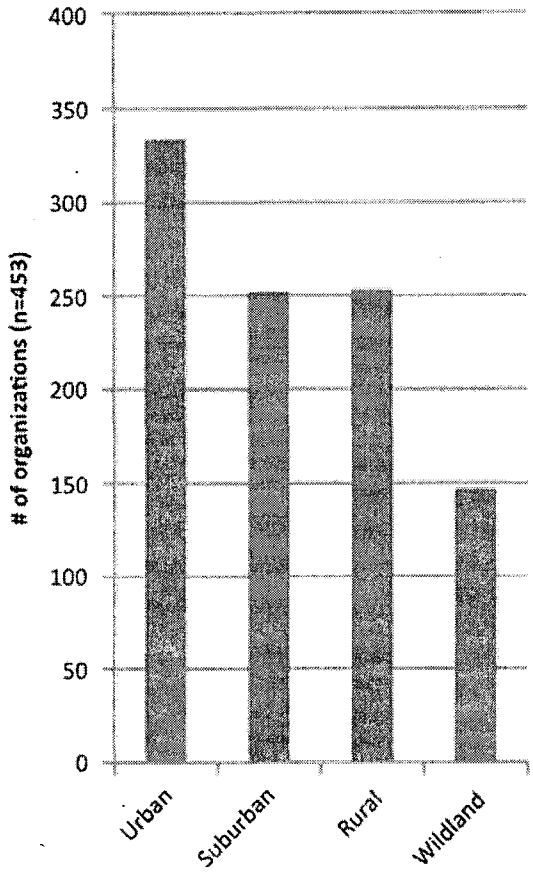

Fig. 3 Number of organizations active across landscape locations (total count greater than 453 due to multiple locations for some organizations)

focus strictly in rural areas and wildlands, with the remaining 43% active in urban and suburban areas.

Projects and activity were dispersed across all ecological systems. Seattle is bounded to the west by the Puget Sound, and to the east by Lake Washington, and also has multiple smaller scale freshwater systems. While 88% of the organizations do at least some work in terrestrial ecosystems, 58% either focus on, or do some work on aquatic resources. Specifically, 22% focus their stewardship on water, with 12% working almost exclusively with water. And finally, 83% of the groups conduct stewardship in multiple, rather than one, project sites.

We also accessed 337 mission statements from web sources. An organization's mission statement is a public statement of principle and commitment. The process of generating a statement often yields motivating sentiments and an organization's social identity. Statements were merged into a single document, with derivatives (e.g., community and communities) combined, and trivial words removed (e.g., a, and, this). Table 3 lists a frequency count of the ten most used terms. The text file was uploaded to Wordle, an online word analysis program that generated a visual representation of word counts (Fig. 4). Word size denotes greater frequency of use across all mission statements. The term "environment" figures prominently, as expected. The pronounced emphasis on "community" (from a social, rather than ecological perspective based on phrasing review) came as a surprise, and indicates that stewardship organizations intend a broad range of inter-related ecosystem and social outcomes within their programming and action. The emphasis on community may also reflect the interests of the volunteer-based work force that comprises civic ES.

Table 3 Stewardship organization mission statements word count ($n=337$)

Community	152
Environment	104
Education	85
Provide	76
Health	72
Protect	62
Promote	61
People	59
Sustainable	58
Work	52

A landscape context–Puget Sound

Why would it be important to know about the intent and extent of stewardship across a large landscape area? As in many regions of the nation and world, a major nearby ecological system provides identity to, but is challenged by built systems. The major cities of Washington State are located on the shores of Puget Sound. The health of this large estuarine system has been stressed significantly, and can only be restored by planning and management responses that engage the public (Puget Sound Partnership 2008). It is also a large and complex socio-ecological system that offers the opportunity to test multiple (and nested) hypotheses.

The Puget Sound is a major estuarine area that spans governmental jurisdictions of the United States and Canada. The surrounding urbanized watersheds support a population of 4.1 million, and are expected to attract an additional three million human residents in the next 20 years (Washington State Office of Financial Management 2007). Local governance of the estuary system includes 12 counties. King and Pierce counties contain 2.5 million residents, representing 42 % of the total population of the State of Washington (U.S. Census 2000). The two counties make up the largest metropolitan region of the state, and include the cities of Seattle and Tacoma. These cities and others within the basin are concentrated around the Sound, are bounded by the Cascade Mountains to the east and Olympics to the west, and are surrounded by national forests, parks, and wilderness areas. There are few places in the world like the Puget Sound Basin, as it contains a steep gradient of landscape types and land uses ranging from urban to wildland, and from mountains to sea.

Fig. 4 Word-use frequencies in stewardship organization mission statements (Wordle)

There are widely shared concerns about Puget Sound ecosystem health and the feasibility of recovery. Despite the breathtaking appearance of this estuarine system, many of the processes supporting diverse species and ecosystem services have been disrupted or severely degraded by urbanization. The decline of the Puget Sound ecosystem is alarming, and multiple organizations at the federal, state, and local levels have launched citizen-based ES programs as a key strategy to address recovery goals. The Puget Sound Action Agenda (authored by the Puget Sound Partnership 2008) is a state level policy that prioritizes basin-wide as well as area-specific efforts, and creates programs that address the complex interactions across land, water, species, and human needs. The Action Agenda calls for the use of stewardship activities to aid recovery and sustainability efforts. Recovery efforts in other major estuarine areas (such as the Chesapeake Bay and the Everglades) point to the necessity of engaging citizens in action on behalf of an ecosystem at risk (Gentile et al. 2001; Holling 2001; Lotze et al. 2006).

A wide range of stewardship activities, representing large investments of public and private funds and human resources, are being initiated to address Puget Sound ecosystem recovery. However, there is little coordination of these efforts, and there no virtually no research on the effectiveness of existing or proposed ES programs, projects, and policies in the region. In fact, there is little research that has adequately characterized the extent, organization, and value of ES across any major watershed basin. Thus, the GCRA is providing the first systematic effort to understand and evaluate the ES of a large estuarine system.

Discussion and research needs

The combined pilot studies reveal an extensive 'shadow network' (Sendzimir et al. 2008) of connected, motivated stewardship activity within the socio-ecological system of the Puget Sound basin. Larger ES organizations have relationships with the environmental agencies that enact top-down recovery programs (such as receiving project grants) so there is institutional acknowledgement of bottom-up stewardship activity, but the full extent of ES contributions is likely underestimated (based on anecdotal response to the census). Nearly 600 environmental stewardship organizations are operating in and around the two largest cities in the Puget Sound Basin. Most are non-profits, but the diversity of organizational structures, legal status, and missions, and the landscapes and ecological systems in which these organizations operate, highlights potential capacity of these activities, and the need for the coupled human-natural systems research being proposed by GCRA.

The existing literature, the breadth and potential scope of ES activities, and the size and complexity of the Puget Sound social ecological system, suggest several important research needs. Future research is needed to develop an ES typology, map ES locations and activities, develop a framework for integrating ES activities and regional environmental policies, and evaluate the effectiveness of civic engagement as a strategy for delivering ES programs and meeting system-wide sustaining goals.

Develop a comprehensive typology of civic stewardship organizations and programs

The term "environmental stewardship" spans extensive and loosely defined activities, ranging from private property owners' management of family forests to city residents participating in a Saturday morning neighborhood park clean up. In an era of declining public budgets, public agencies and environmental organizations need to engage citizens in

order to provide essential stewardship services for land management for diverse purposes and across the entire landscape gradient, from urban to wildland settings. Response to identified environmental issues and threats is ostensibly the most direct goal of ES. Considering the cognitive maps of seasoned stewardship professionals and organizational mission statements, the combined data sets indicate nearly comparable emphasis on social goals, especially the themes of building and enhancing community, and education. The interplay of individual values with organizational effectiveness was also highlighted by practitioners.

While organizations share socio-ecological goals in a general sense, many organizations align their activity with a self-defined mission, and operate independently of others. Coalitions and partnerships are ad hoc, with some encouragement from agencies. In order to attain the full potential of ES as a land and ecosystem management strategy, a complete assessment and classification of organizations and activities would be valuable. A typology should include organization structure and purpose, activities, leadership styles, and participant base, as well as other attributes. This would clarify the range of human and organizational capacity that could be brought to bear on ecosystem health and recovery at a large geographic scale, such as the Puget Sound basin. An ES classification would provide a conceptual array of stewardship that would provide a shared and clearly articulated set of assumptions, values, and definitions to guide comprehensive stewardship planning and development (Romolini et al. in review). From a practical standpoint a classification could enable more effective goal setting, resource delivery, and coordination of effort by agencies as they work with organizations at the landscape scale.

The pilot studies provide the basis of a classification scheme. Mixed methods approaches would expand the knowledge base necessary for sorting organizations. First, we will expand the organization census survey reported above to replicate a stewardship mapping project that was conducted in New York City (Svendsen and Campbell 2008). This will expand the organizational census data and its reliability. Then, we will use social network analysis to identify the informal and formal networks of relationships and resource flow (Scott 2006; Granovetter 1985) using node and connectivity 'maps.' Similar investigations of stewardship organizational networks are in development as part of the Baltimore Ecosystem Study and Chicago region. Finally, from the network study, we will conduct analyses that will assess patterns of innovation, entrepreneurship, and collaborative capacities that characterize grass-roots communities of practice.

Develop a comprehensive geospatial representation of organizational locations and activities

Stewardship activity, particularly in urban areas, accommodates social dynamics, but its fundamental purpose is to effect positive change on the land. Geospatial analysis has become an essential tool to record and visualize attributes and change across both human and ecological systems. Geographic tools and products readily depict variability within systems using symbol, color, and scale. Initial census data of 600 organizations, although limited in the number of attribute records, quickly exceeded one's capacity to comprehend the full implications of the assessment beyond simple descriptive statistics of the population.

A geospatial database would enable a comprehensive and cumulative estimation of stewardship in relation to place and ecological systems. Geospatial recording of organizations by classification could be related to landscape unit mapping. Relative levels of stewardship presence, activity and outcomes can be visually represented across diverse

landscape types, land uses, and settlement patterns of the region. A geospatial data set would include relevant landscape, ecological, and social archival data (such as provided by USGS, the US Census, and state level data sets).

Geospatial data can first become the basis of descriptive and then predictive analyses of ES impacts. Geospatial tools can visually display the extent and temporal flux of a stewardship footprint, record environmental outcomes, and reveal the cumulative effects of ES programs and activities. The data approach might also include social mapping of multi-method results, such as results of survey, interview, or focus group based data. Geospatial records of ES activities offer opportunities for development of theory about adaptive management of urban natural resources and practical applications for system-wide interventions for stewardship management (such as delivery of grants programs or technical information).

Mapping the ES footprint will be difficult and expensive, and it will require several research phases and additional resources. In the short run, GCRA will use the organizational network analysis to identify location of recent stewardship activities for each ES group and map the spatial extent of those activities using line, point, and polygon data. Contingent on future funding, we plan to conduct a more detailed analysis of the specific types of ES activities, and the environmental and social outcomes of the work, in one or two Puget Sound watersheds. Over time, we hope such methods will become a regular part of the activities of the key ES organizations, and the geospatial data will be collected on an ongoing basis and used to design policies and program to help meet the Puget Sound Action Agenda.

Integrate stewardship with ecological policy, priorities, and monitoring

The interviews, and mission statements of organizations in the census, indicated the primacy of commitment to ecosystem health and recovery across diverse landscape contexts, including areas that contribute to Puget Sound health. Yet there was little (if any) indication of routine ecological health assessments or monitoring of their ES work. Thus an important scientific contribution to the region would be to devise, manage, and analyze the ecological consequences of stewardship programs.

Such work could include several elements; each could be mapped to become geospatial data layers. First, an assessment of the policy and monitoring programs now in place for ecosystem and natural resources recovery would help to establish priority areas and activities for ecological action. Within the Puget Sound watershed 21 species are federally listed as threatened or endangered, including orca whales (*Orcinus orca*) and Chinook salmon (*Onchorhynchus tshawwytscha*). More than 1,000 rivers and lakes are listed as impaired, and there are ecological "dead zones" in Hood Canal and the South Sound (Puget Sound Partnership 2008). In response agencies and organizations, from federal to local, have issued policy and program recommendations for habitat and ecosystem recovery. Many of these are place-based, such as nearshore vegetation management. Compiling and spatially delimiting these recommendations could help align broader ecological goals and objectives and stewardship project sites.

Second, increased computing and remote sensing capacities have enabled development of extensive, detailed data sets for large-scale landscapes. The absence or decline of resources as determined by analysis using such data sets could also serve to focus stewardship activity. For example, an urban forest canopy analysis was conducted by the City of Seattle (2007). Identification of canopy voids has spurred city government support of volunteer-based tree planting in specific neighborhoods. More

precise resource mapping and analysis combined with follow-up stewardship programs could be extended to a broader set of urban ecological systems (such as watercourses and patch forests).

Finally, ES could incorporate citizen science programs that conduct monitoring. To address increasing field science needs, investigators are more frequently using motivated, trained amateurs to assist with data collection (Delaney et al. 2008; Cohn 2008). Ecological projects range from local to global and monitor a broad range of plant and animal taxa, and citizen scientists regularly contribute data on weather and habitat (Dickinson et al. 2010). Citizen science projects in the Puget Sound region include salmon and seabird surveys, and toxins and water monitoring (Litle et al. 2009). Citizen data collection is facilitated by formal research investigations that are aligned with ecosystem recovery goals, yet there is no basin wide inventory of the number or extent of the citizen science projects. A more formal network could generate greater return on effort towards recovery goals. Based on the dual emphasis of ecology and community in organizational mission statements, citizen science projects could be community-based, building on motivations of access convenience and place attachment. As an example, the City of Seattle has contracted for ecological monitoring of several urban forest demonstration sites, with field work to be assisted by citizens, and results will be used to focus restoration work of neighborhood-based work parties and to evaluate recovery outcomes over time.

Assess and test civic engagement strategies to expand participation in ES

Government agency programs alone are not adequate to address ecological health issues, and regulatory approaches are hampered by political and enforcement realities. Civic engagement, defined as "how an active citizen participates in the life of a community in order to improve conditions for others or to help shape the community's future," is associated with a number of individual and collective societal benefits (Adler and Goggin 2005, p. 236). One form of civic engagement, citizen based ES, is increasingly enlisted to achieve ecosystem health and recovery goals and objectives. Indeed, lack of involvement of key participants in urban greening projects has been linked to project failure (Yang and Jinxing 2007).

Assessment and testing of engagement strategies should occur at two scales. The census indicated the breadth of ES organizational structure (from local agencies to NGOs) and activity locations (from urban to wildland). Most organizations are dependent on volunteers to conduct their programs (Ryan and Grese 2005). Within the census findings, it appears that some programs have sophisticated engagement strategies and others are more ad hoc. A comprehensive understanding of these strategies is lacking. Better understanding of the procedures used to recruit, train, and retain participants would provide a shared resource across the region. Research to evaluate and test best practices could support a region-wide engagement network that offers more efficient and coherent volunteer administration. For instance, a one-stop web site could serve as a regional events calendar that is relational to an organization typology, activity locations, and ecological action needs.

Our practitioner interviews also judged that value sets concerning the environment, personal ethics, and local community were important to individual motivation in stewardship. These initial interpretations serve as a set of working hypotheses that can be further explored using a range of qualitative and quantitative social science methods. The broader literature on volunteerism notes personal motivations of career opportunity, personal values, social interactions, and learning (Clary et al. 1998; Bruyere and Rappe

2007). Confirmation of these within the realm of ES, as well as understanding project-based variability of motivations, perhaps associated with types of activities or locations across the landscape gradient, and social or place affiliations, would enable recruitment of broader populations for environmental work (Moskell et al. 2010).

Conclusions

Our pilot studies indicate that there is a large and organized, but not necessarily synchronized civic resource dedicated to urban-based restoration and conservation. The organizational census revealed extensive ES activity across the entire landscape gradient, expressed as wide ranging and variable programs with interests in coupled human and natural systems outcomes. Many urban ecology investigators would limit their interest or collaboration with stewardship volunteers to interactions focused on biophysical outcomes. Yet experienced ES practitioners noted the importance of social community in their response themes, including *community building*, *citizen engagement*, *concern for community*, and *collaborating*.

Research on collaborative resource management acknowledges the importance of local citizen engagement, but case studies appear to treat citizen contributions with a tone of administrative utility. The implication is that collaboration leads to better conditions for a resource in question or a better decision-making process. Our preliminary work indicates that a person may participate in urban-based, civic environmental stewardship on behalf of a resource system, but does so to also generate direct personal benefits for better conditions in a neighborhood or other social community. A research program that scales up from the individual to the region can aggregate such close-to-home values and experiences, using social mapping and geospatial tools, to monitor landscape system change and determine outcomes are consistent with broader recovery goals and programs.

Based on our pilot studies we offer a working definition of successful urban-based, civic environmental stewardship. Environmental stewardship in cities engages citizen volunteers in collective action to restore, conserve, or better understand specific environments or landscapes, and simultaneously meets personal health and well-being goals, and achieves healthier social relationships through community building and collaboration.

About 80% of the U.S. population now lives in urban areas; the rate is at more than 50% across the planet. Urbanization presents a duality of conditions and landscape impacts. On one hand increased human density poses a range of alterations and threats to natural systems, and recent ecological science generates better understanding of such changes. On the other hand, if urbanized settings are planned, designed, and maintained in such a way as to compel people to manage and steward their nearby natural and social communities, it may be possible to conserve ecological processes and actual landscapes within urbanized areas. Declining ecosystem health of the Puget Sound presents a timely opportunity to study and inform a necessary transition to a culture of stewardship. To meet sustainability goals for complex, urbanizing systems in general, we need a better understanding of the potential positive effects of human agency on the environment. We need more research on the 'environmental stewardship footprint'.

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