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## **Applying a Resilience Systems Framework to Urban Environmental Education**

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### **Abstract**

A growing body of literature on community gardening, watershed restoration, and similar “civic ecology” practices suggests avenues for integrating social and ecological outcomes in urban natural resources management. In this paper, we argue that an environmental education programme in which learning is situated in civic ecology practices also addresses both community and environmental goals. Further, we suggest that civic ecology practices and related environmental education programmes may foster resilience in urban social-ecological systems, through enhancing biological diversity and ecosystem services, and through incorporating diverse forms of knowledge and participatory processes in resource management. By proposing interrelationships among natural resources management, environmental education, and social-ecological systems, we hope to open up discussion of a research agenda focusing on an “ecology of environmental education.”

*Keywords:* Resilience, Systems, Urban, Diversity, Participation, Civic Ecology

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## Introduction

Incorporating social and ecological perspectives in environmental education (EE) is particularly important in cities, where the human imprint is most obvious and where over 50% of the world's population lives (UNFPA, 2007). EE that includes an action component, such as action competence that focuses on issue identification, analysis, and in some cases advocacy, is one model for integrating social and ecological concerns (Jensen and Schnack, 1997). In an analysis of multiple environmental action programmes across the USA, Schusler and Krasny (2008) suggest that in addition to public issue analysis and advocacy for policy change, such programmes may involve participants in community development and in hands-on activities to enhance the natural and built environment.

Parallel to EE approaches that “couple” social and ecological outcomes, a new type of environmentalism is emerging in North American cities, which in contrast to the traditional environmental movement's focus on preserving pristine landscapes, integrates community and ecological values. Various labels include civic environmentalism (Light, 2003), urban ecological stewardship (Svendsen and Campbell, 2008), urban restoration (Stevens, 1995), ecological restoration (Palamar, 2008), or civic ecology (Tidball and Krasny, 2007), this movement involves citizens, non-profit groups, and government in restoring nature in cities through such activities as planting trees along river corridors, community gardening, and recreating native wildlife habitat. Although in some cases these activities involve advocacy (*e.g.*, demonstrations in favor of managing land for community and environmental rather than economic values), the emphasis is on restoration or stewardship practices. Residents who take on the stewardship of plots of land or sections of streams that have fallen into neglect not only enhance local ecosystems, but may also build social networks and otherwise contribute to community well-being (Light, 2003; Palamar, 2008; Svendsen and Campbell, 2008).

We have proposed the term civic ecology to refer not only to these urban restoration and stewardship practices, but also to a theoretical framework for studying the role such practices play in the larger social-ecological system (Tidball and Krasny, 2008). A number of bodies of literature focus on the integration of the social and ecological sciences, including human ecology, which encompasses a broad and diverse set of ideas about human-environment interactions (Borden, 2008); social ecology, which generally refers to a radical stance arguing against political domination, hierarchy, and capitalism as causes of environmental degradation (Bookchin, 1993); environmental justice, which emphasizes advocacy, rights to a clean environment, and organizational networking (Faber and McCarthy, 2001; Palamar, 2008); and collaborative approaches to natural resources planning and management, in which public and private stakeholders engage in conservation planning (Schlosberg and Dryzek, 2002, Schusler *et al.* 2003). Civic ecology more specifically examines stewardship practices that integrate social and environmental values within a social-ecological systems framework. In so doing, civic ecology differs from the above approaches in two ways: (1) It shifts the focus from power, individual rights, advocacy, and planning to people acting as stewards of their environment through such practices as community gardening, community forestry, and watershed restoration. Such practices create opportunities for individuals, including those

in cities, to experience the health and restorative benefits of gardening, habitat restoration, and other forms of stewardship. Civic ecology practices also allow individuals to learn through observing and experiencing how their actions impact the biological (including plants, animals, and other humans) and physical environment, as well as the feedbacks and other interactions among their actions and other ecosystem components. (2) Civic ecology applies a specific social-ecological systems framework, *i.e.*, resilience (Resilience Alliance, 2008), to examine the interactions of humans with other forms of life and with the physical environment, as well as the outcomes of stewardship (or civic ecology) practices.

Civic ecology's focus on active engagement with nature draws from notions of biophilia (Wilson, 1984) and nature deficit disorder (Louv, 2006), and suggests that restoring nature may contribute to individual well-being (Miles *et al.*, 1998). Moving from the individual to community level, civic ecology practices are closely tied to civic engagement, and thus may foster such community-level attributes as social trust, social connectedness, associational involvement, and other aspects of social capital (Palamar, 2008; Putnam, 1995). Finally, civic ecology poses questions about the role of stewardship practices, *and* of EE programmes situated in these practices, in fostering desirable properties of social-ecological systems, including resilience or the capacity of a social-ecological system to buffer perturbances and to renew and reorganize in response to change, (Folke *et al.*, 2002). Thus, civic ecology suggests a role for environmental stewardship practice and EE at the level of the individual, community, and social-ecological system.

While recognizing the existence of other natural resources management frameworks that have been applied to stewardship practices (*e.g.*, the Human Ecosystem Framework, Machlis *et al.*, 1997; Svendsen and Campbell, 2008), we have chosen a social-ecological systems resilience framework for examining civic ecology practices and related EE programmes for the following reasons. First, the resilience framework is attentive to complexity, non-linearity, unpredictability, and other factors that impact the outcomes of EE; thus, it challenges environmental educators to look beyond behavioral and other individual-level outcomes and consider the role of EE in fostering the well-being of larger social-ecological systems (Sterling, 2003). Second, resilience theory incorporates response to change; because all social-ecological systems face disturbance or change (including catastrophes such as hurricanes, earthquakes, and ethnic conflict, as well as more gradual change such as increasing crime or shifting demographics), a focus on system response to change adds an important dimension to considerations of sustainable development and ESD. Third, a resilience framework has been used for examining the role of civic ecology practices in helping communities respond to change, including community forestry as a means for neighborhoods to rebuild social and natural capital following Hurricane Katrina (Tidball and Krasny, 2008) and community gardening as a response to change brought about by industrial agriculture (King, 2008). Such civic ecology practices provide opportunities for situating learning in real-life resource management efforts in cities; examining such learning using a resilience framework can contribute to our understanding of the role of EE in broader community and environmental sustainability. In short, a resilience framework challenges us to consider

the role of EE within a broader social-ecological system, can be readily linked to and builds on notions of sustainability, and suggests ways to situate learning in natural resources management practices in cities and in the other “peopled landscapes” or anthropogenic biomes, which increasingly dominate the earth (Crouch 1992, Ellis and Ramankutty, 2008). Further, through incorporating notions of feedback loops and nested systems (Gunderson and Hollings, 2001), a resilience framework allows us to pose questions about how stewardship practices, EE, and ecological and social system health might reinforce each other, and thus suggests an “ecology of EE” (Tidball and Krasny 2009).

In the remaining sections of this paper, we first provide a brief overview of the resilience framework. We next describe an example civic ecology practice (community gardening), and an EE programme situated within this practice (Garden Mosaics), following which we apply the resilience framework to examine the potential impacts of community gardening and other civic ecology practices and of EE situated in such practices. By applying the resilience framework to EE situated in ongoing civic ecology practice, we extend the application of resilience principles from natural resource management to stewardship and education. By applying resilience thinking in cities, we are able to focus on systems that are increasingly important globally (Brunn, 2003; Parlange, 1998; UNFPA, 2007) and to highlight cases of integrated social-ecological practice in resource stewardship (Light, 2003).

Thus, the major contributions of this paper to the EE literature are two-fold. First, by addressing the implications of a growing urban environmental stewardship movement for environmental education, we present new ideas about the cross-over between natural resources management and EE. Second, by adding a resilience perspective, we elaborate on systems thinking in EE (*c.f.*, Sterling, 2003) and focus the debate on the importance of EE to the overall social-ecological system. Whereas Sterling (2003) presents a thorough theoretical discussion of the role of systems thinking in EE, we focus more specifically on exploring the application of resilience systems thinking to practical examples of education programmes, particularly in urban areas. Other authors have focused on teaching systems thinking (*e.g.*, Jacobson and Wilensky, 2006), or have used the term socio-ecological to refer to environmental learning within real-life situations such as family households and sports grounds, including the people involved and issues that arise in these contexts (Kyburz, *et al.*, 2006). Building on these important approaches, we suggest that: (1) EE can be situated in civic ecology practices that foster social-ecological systems resilience, and (2) the EE programmes themselves can be examined in terms of their role in larger social-ecological systems.

While suggesting potential resilience outcomes of EE situated within civic ecology practice, we recognize that it is too early to make definitive claims about this approach. Thus, the goal of this paper is to open up a discussion of applying resilience systems thinking to EE. In so doing, we hope to stimulate potential new lines of research, including questions focusing on outcomes of EE related to attributes of resilient social-ecological systems (*e.g.*, social capital, biological and cultural diversity, ecosystem services, *c.f.*, Walker and Salt 2006). Applying resilience systems thinking to EE also

suggests research questions related to the feedbacks among EE, stewardship practices, and the physical, biological, and social components of a system, or what Tidball and Krasny (2009) have referred to as an “ecology of EE.”

### **Resilience in Social-Ecological Systems**

Folke *et al.* (2002) have pointed out that in managing ecosystems for stability and productivity, and in decoupling human and natural systems, we inadvertently reduce the ability of social-ecological systems to respond to change. So, for example, to increase forest productivity, we plant mono-specific, even-aged stands that may be unsustainable in the face of perturbations (*e.g.*, insect infestations, climate change), and that may not support local people who depend on multiple ecosystem services provided by forests, such as food, fiber, fresh water, flood regulation, and opportunities for cultural expression (*c.f.* MEA, 2005). In contrast, systems that incorporate ecological diversity, as well as diverse forms of knowledge, multiple levels of organization including those based in community participation, and adaptive learning, are likely to be more resilient in the face of small-scale change and disasters. Because change is inherent to all systems, resilience is an integral component of sustainability (Folke *et al.*, 2002). The relationship of resilience to sustainability is further spelled out in the following quote.

(M)anaging complex, coevolving social-ecological systems for sustainability requires the ability to cope with, adapt to and shape change without losing options for future development. It requires resilience—the capacity to buffer perturbations, self-organize, learn and adapt. When massive transformation occurs, resilient systems contain the experience and the diversity of options needed for renewal and development. Sustainable systems need to be resilient. (Folke *et al.*, 2002, p 51).

The resilience framework has roots in systems dynamics thinking, which includes an emphasis on causal feedback loops rather than linear causality. System dynamics entails making three fundamental shifts of mind relative to traditional ways of thinking: (1) from linear, laundry list thinking to a circular, closed-loop view of causality; (2) from an external to an internal focus on performance, emphasizing how we, not others, are responsible for results; and (3) a focus on an operational view of how things work in contrast to analysis methods based on statistical correlation of past trends (Walkers, 1997). According to Richardson (1997), “Systems dynamics thinking gets a lot of its power from a 'feedback' perspective -- the realization that tough dynamic problems arise in situations with lots of pressures and perceptions that interact to form loops of circular causality, rather than simple one-way causal chains.” Resilience thinking also draws from the adaptive cycle as a metaphor for how change occurs, with periods of rapid growth and stability alternating with decline followed by reorganization. Managing for change, rather than toward a stable state endpoint, is inherent to resilience thinking (Resilience Alliance, 2008).

Systems scholars have cited three attributes as being fundamental to the ability of a social-ecological system, or of a community nested within that system, to respond to rapid changes and uncertainty, including: (1) the amount of change the system can

undergo and still retain the same controls on function and structure, (2) the degree to which the system is capable of self-organization, and (3) the ability to build and increase the capacity for learning and adaptation (Folke *et al.*, 2002). Walker and Salt (2006) list nine rather than three attributes that characterize resilient social-ecological systems, including diversity, ecological variability, modularity, slow variables, tight feedbacks, social capital, innovation, overlap in governance, and ecosystem services. In the interest of space limitations, we focus our discussion below on Folke *et al.*'s (2002) more limited set of factors, while recognizing that Walker and Salt's (2006) expanded list provides greater opportunity for posing questions about the potential for EE to contribute to multiple attributes of resilient social-ecological systems.

According to resilience scholars, diversity is fundamental to retaining functional and structural controls in the face of disturbance and thus to buffering the impact of catastrophic and more gradual change (Folke *et al.*, 2002; Perrings, 2006; Walker *et al.*, 2006). Levin (2005) describes how biological diversity can provide functional redundancy, so that if one species declines other species providing the same ecosystem services may continue to function. For example, if a plant community has several species capable of fixing nitrogen, the decline of one of those species may have limited impact given that other species continue to add nitrogen to the system. However, in a review article, Thompson and Starzomski (2007) caution that although biodiversity may be positively associated with the ability of systems to respond to change, not all systems with higher biodiversity will be more stable under changing conditions.

Resilience scholars also claim that when diverse groups of stakeholders, such as scientists, community members with local knowledge, NGOs, and government officials, share the management of a resource, decision-making may be better informed, stakeholders may be more invested in and supportive of the decisions, and more options exist for testing and evaluating policies (Olsson *et al.*, 2004). Thus, diverse forms of knowledge, including traditional ecological and scientific knowledge, may be critical in managing social-ecological systems (Berkes, 1998; Berkes *et al.* 2000).

Self-organization refers to the emergence of macro-scale patterns or properties from smaller-scale rules, such as the emergence of ecosystem patterns related to nutrient cycling or plant size distributions as a result of evolution acting at the species level (Levin, 2005). Olsson *et al.* (2004) apply the concept of self-organization to humans managing social-ecological systems, claiming that when private landowners, scientists, and professional land managers work together to design and learn from management practices, adaptive co-management is the resultant emergent property. The authors describe two rural examples of adaptive co-management, one involving fishermen and lakeshore owners who responded to an acid rain threat in Sweden, and the other involving indigenous peoples whose way of life was threatened by hydropower development.

The capacity for social and adaptive learning is a third attribute of resilient social-ecological systems (Plummer and FitzGibbon, 2008). Pahl-Wostl *et al.* (2007) suggest that learning among groups restoring a watershed results from an interplay among three

elements: context formed by institutions and physical system, process formed by management practices, and outcomes that change the original context. The story of volunteer efforts to restore degraded prairie and savannah habitats in Chicago provides a case study of how, through a series of informal planting and land management experiments (*e.g.*, controlled burns to suppress invasive species), civic ecologists learned adaptively how to enhance the ecosystem services provided by urban open space (Stevens, 1995).

In short, according to the resilience framework, diversity (including biological diversity and diverse types of knowledge), self-organization, and adaptive learning are three attributes of social-ecological systems that are able to adapt to disturbance and change, although other factors also play a role. Currently, social and ecological scientists are applying this framework to forest, aquatic, marine, agricultural, and urban social-ecological systems using case study and other methodologies (Alberti and Marzluff, 2004; Anderies *et al.*, 2002; Baskerville, 1995; Carpenter and Cottingham, 1997; King, 2008; Resilience Alliance, 2008; Tidball and Krasny, 2007).

Below we add to the existing literature by describing how the attributes of resilient systems are embodied in one type of civic ecology practice in cities, *i.e.*, community gardening. We then present an example of an EE programme, Garden Mosaics, that is situated within this civic ecology practice, and discuss the potential of this and similar educational programmes to contribute to social-ecological system resilience. In suggesting that a specific educational intervention has the potential to enhance a system's resilience, we depart from the existing literature, which has focused primarily on applying the resilience framework to understanding the functioning of social-ecological systems. Whereas the Garden Mosaics EE programme was not originally designed with resilience principles in mind, we have found the framework useful in posing questions about the programme's potential impacts, and about its relationship to community gardening practice and to the larger system in which it is situated.

### **Urban Community Gardening Practice and Education**

In the USA and Canada, urban community gardeners often are new immigrants from developing countries, as well as African-Americans who have migrated to cities from the rural southern states. These individuals bring with them a form of experience-based, practical, or "traditional ecological" knowledge of plants and planting practices, which they adapt to the new urban sites where they have relocated. As a result of the gardeners' efforts, community gardens provide important ecosystem services (MEA, 2005) to people with limited access to other more natural areas. These services include opportunities to enjoy nature, learn about biological and cultural diversity, obtain fresh produce, get exercise, form social networks, and escape from the noise and stress of urban living (Armstrong, 2000; King, 2008; Patel, 1991; Saldivar-Tanaka and Krasny, 2004; Westphal, 2003). Further, through integrating biological and cultural diversity, diverse forms of knowledge (*e.g.*, knowledge of immigrant gardeners and of scientists conducting research at these sites), participatory action, flexible social institutions, and adaptive learning, community gardens may be contributing to social-ecological system resilience in cities (King, 2008; Tidball and Krasny, 2007).

Rogoff *et al.* (2003) and other socio-cultural theorists speak to the importance of situating learning in authentic practice. Because urban community gardening is an example of resource management that integrates social and ecological values, it provides an opportunity for environmental learning situated within local practice. Further, if in fact community gardening contributes to resilience in urban social-ecological systems, embedding an EE program within community gardening may enhance resilience in cities.

Fusco (2001) describes a case of a youth science inquiry programme situated within a community garden in NYC. Similarly, Garden Mosaics is an EE programme that takes place in community gardens in North America and elsewhere, and integrates science and environmental learning, civic action, and multi-cultural and intergenerational understanding. Youth learn alongside adult community gardeners, who share their knowledge of plants and how plants connect to the gardeners' cultures and traditions. In addition to their experiences gardening alongside experienced gardeners within a community context, youth in Garden Mosaics learn about ecology and agriculture through short-term inquiry activities, conduct investigations in which they explore questions about social and ecological components of the garden and neighborhood, and conduct action projects to enhance the garden and neighborhood (Textboxes 1 and 2).

### Textbox 1. Garden Mosaics Learning Activities

Youth activities, including *i-m-science investigations*, Action Projects, and other shorter-term learning exercises, build on scientific and traditional knowledge, and civic values in community gardens. For example, in the Gardener Story *i-m-science investigation*, youth interview immigrant and African-American gardeners about their knowledge of plants, planting practices, and the connection of plants to their cultural traditions. Names of plants and planting practices from the gardeners' stories are linked to Science Pages, which include science-based content and protocols for short-term learning activities. Youth also use problems or needs related by gardeners to develop garden and community Action Projects. Youth submit the results of their *i-m-science investigations* and Action Projects online, where others can view their findings.

#### *i-m-science investigations*

- *Neighborhood Exploration*, in which youth explore the assets of their community using spatial imagery, and observations and interviews conducted while walking around their neighborhood.
- *Gardener Story*, which entails interviewing a gardener about the connections between planting practices and cultural traditions.
- *Community Garden Inventory*, in which participants list the activities and other services community gardens provide for their neighborhood.
- *Weed Watch*, designed to collect data about weed problems and control methods in urban gardens.

**Action Projects**, in which youth apply what they have learned in their *i-m-science investigations* to enhancing their neighborhood or community gardens. Example Action Projects include youth building a handicap-accessible raised bed, conducting a neighborhood garden festival, donating produce to food kitchens, creating a plant sculpture in a garden, and sharing what they have learned with younger children.

**Short-term inquiry and other learning activities** ranging from jeopardy games focused on food crops to blog exchanges with youth overseas.

(Krasny *et al.*, 2005, 2006)

## **Textbox 2. Example Garden Mosaics Youth Programmes**

### ***Sacramento California***

In Sacramento, youth interviewed Hmong community gardeners about what they were growing and the cultural relevance of their plants. The youth compiled a list of insects in the gardens with both the English and Hmong names. They also learned that there was a long waiting list for plots at the community garden, so they designed a new community garden for elders and youth next to their high school.

### ***Bronx, NYC***

In the Bronx, Abraham House provides an alternative to incarceration for first time offenders and support services for their families. The youth in their summer programme conducted an interview of an elderly Mexican gardener at the nearby Bronx Cultural and Community Garden, and posted what they learned on the Gardener Story database. Abraham House staff and a Cornell graduate student worked together to guide the youth in inventorying weed problems, and entering their data on the Weed Watch database. The youth created a poster of their Weed Watch activities, which they presented at the annual meetings of the Weed Science Society of America. Later the youth used a blog to share their garden and neighborhood activities with youth conducting Garden Mosaics activities in Tomsk, Siberia.

### **Applying the Resilience Framework to Community Gardening and EE**

Below we apply the attributes of resilient systems to an analysis of urban community gardening and the Garden Mosaics EE programme. In the interests of conserving space, we focus on two attributes that are directly addressed through community gardening and the Garden Mosaics programme: diversity and self-organization. In future papers, including a forthcoming Special Issue of *Environmental Education Research*, we will expand our discussion of resilience and EE to include additional attributes of resilient systems including adaptive learning (Armitage *et al.*, 2008) and social capital (Adger, 2003), a more thorough discussion of resilience concepts (*e.g.*, adaptive cycle, feedback loops, and panarchy; Resilience Alliance, 2008), and a wider array of EE programmes focusing on watersheds, community forestry, and wildlife habitat restoration in community, formal, and higher education settings.

**Diversity.** Community gardens often include a rich diversity of vegetables, herbs, trees, and flowering plants, although many of the species are introduced. In cities where community gardens are common, they contribute significantly to overall green space and biodiversity (*e.g.*, provide sites for migrating birds, Tidball, 2007; Gutierrez and Vargo, 2007), as well as to landscape heterogeneity (an attribute of resilient systems, Walker and Salt, 2006). Community gardens may provide the only opportunity for residents in some urban neighborhoods to experience biodiversity or nature, and as such they may foster psychological and physical health (Louv, 2006) and provide opportunities for learning (King, 2008). For these reasons, community gardens may contribute to the resilience of social-ecological systems, or of communities nested within those systems, in the face of such perturbances as demographic shifts, food insecurity, ethnic conflict, or floods and other catastrophes (Tidball and Krasny, 2007).

Urban community gardens also represent sites where individuals holding diverse practical and scientific knowledge come together, including community gardeners and staff of non-profit organisations, government agencies, and universities. Whereas most literature on traditional knowledge and natural resources management focuses on indigenous or rural communities in which there is a long history of *in situ* adaptive learning and traditions (*e.g.*, Berkes, 1998), Shava *et al.* (2008) describe how farm communities in Zimbabwe that have been resettled turn to traditional knowledge and crops as a resilience strategy in the face of severe economic and environmental hardship. Similarly, in the case of immigrant and internal migrant urban community gardeners in North America, agricultural knowledge acquired in rural settings has been adapted to new environments. Given that even remote “indigenous” communities are linked into the global economy through migration and international markets (*e.g.*, yak herders in remote villages of Bhutan collect medicinal products and sell them on the global market; Buckley, 2008), it may be that rural as well as urban farmers develop a constantly changing “hybrid” form of local knowledge (Briggs, 2005).

In addition to possessing knowledge of plants, through gardening in a shared public space community gardeners acquire knowledge of urban infrastructure (*e.g.*, water lines), urban natural resources (*e.g.*, sources of uncontaminated soil, sources of fresh food), and local advocacy and politics (related to protecting garden sites from commercial or other

development). Further, refugee and other gardeners who use gardening as a form of personal psychological resilience to trauma and hardship (Helphand, 2006; Slater, 2001; Stuart, 2005) may possess a form of experience-based knowledge about plants and emotional well-being. Consistent with the horticultural therapy literature detailing the psychological benefits of plant-people interactions, the Healing through Community Gardening project in Bosnia-Herzegovina, where people from ethnic groups formerly in conflict work side by side to grow food for themselves and their families (American Friends Service Committee, 2008), provides an example of using the experiential knowledge of individuals (*i.e.*, of how gardening with others can help in reconciliation) for the purposes of community resilience following conflict. Similarly, our observations of Afghani, Laotian, and Liberian refugee, elderly Korean, and war-injured Ethiopian community gardeners in North American cities support the notion that people use community gardening to help in resilience at the individual level (*c.f.*, Luthans *et al.*, 2006), while also building more resilient communities. As an example of how this individual and community resilience may serve to “buffer” the impacts of a disturbance, a number of US cities responded to the 9/11 terrorist attacks by transforming community gardens into “Living Memorial” gardens (Svendsen and Campbell, 2005). Through the lens of resilience thinking, neighborhoods in which residents have diverse forms of knowledge (*e.g.*, of plants, urban infrastructure, and strategies for personal resilience) may have a higher degree of community resilience, which they tap into to help sustain their communities in the face of a disturbance such as a terrorist attack.

Briggs (2005) and Henkel and Stirrat (2001) point out the dangers of romanticizing traditional knowledge, and Reid *et al.* (2002, 2004) describe the contested nature of traditional ecological knowledge and caution about its inappropriate uses in education (*e.g.*, use out of context, “value-through-utility,” romanticizing). Despite these cautions, a number of education scholars and practitioners use traditional knowledge in school science learning, claiming that it is an effective means to engage youth who otherwise feel alienated. Further, when children learn traditional knowledge alongside community members, both the youth and adults may experience enhanced agency and a sense of renewed respect for and pride in the value of their cultural heritage (Aikenhead, 1996; Jegede and Aikenhead, 1999; Fakudze, 2004; O’Donoghue *et al.*, 2007; Masuku van Damme and Neluvhalani, 2004), outcomes which are consistent with ESD (UNESCO, 2005) and which may contribute to resilience at the individual level (Clauss-Ehlers and Weist, 2004). Share Net in South Africa provides an example of integrating traditional knowledge learned from elders into standard life sciences, chemistry, and physics curricula, including lessons on wild edible greens (*imifino*), cholera, and fermented foods (O’Donoghue *et al.*, 2007, O’Donoghue and Russo, 2004). Similarly, in the case of Garden Mosaics, we use local, practical knowledge of gardeners to engage youth and elder gardeners in learning together. If, as suggested by resilience scholars, diverse forms of knowledge foster resilience in a social-ecological system, one might pose the question of whether EE programmes that incorporate such knowledge and that take place in the context of civic ecology practices might also contribute to resilience of the surrounding community.

**Self-organization.** Self-organization, or the emergence of larger-scale patterns from independent smaller-scale processes, may occur when the density of community gardens is high, or when community gardens together with parks, recreation corridors along train tracks, and other types of green spaces contribute to the total green area in a city. In both cases, one can envision a diversity of green spaces, each one initiated and managed somewhat independently, contributing to a larger landscape that provides ecosystem services for city residents (*e.g.*, wildlife habitat, water quality, carbon sequestration). Thus, from an ecological perspective, the organismal processes in a single community garden, such as fruit production, rainwater retention, and photosynthesis, can be viewed as small-scale processes contributing to larger-scale patterns of ecosystem services (MEA, 2005).

The actions of city residents who reach a critical mass of shared frustration with the status quo, and organize themselves to take initiative to remove rubble and replace it with soil to grow crops and trees, embodies a form of community-based self-organization that presents an alternative to dependence on formal institutions (*c.f.*, Folke *et al.*, 2002). A system of adaptive co-management of informal green spaces in cities emerges from the collaborations and adaptive learning among local stakeholders.

Because self-organization is tightly linked to citizen participation, it is useful to consider the existing literature on participation in natural resources management and EE. In the introduction to their edited volume, *Participation: from Tyranny to Transformation*, Hickey and Mohan (2004) argue for moving beyond the debate about whether participation is exploitative in offering solely technical solutions and ignoring power relations, to considering in more depth the outcomes of various forms of participation, including “participatory spaces.” In the context of civic ecology, participation sometimes occurs in what Gaventa (2004) refers to as “claimed or created spaces,” in which less powerful actors with a common set of concerns or identities claim spaces from more powerful players. An example of this type of participation is the community gardening movement in the late 1970’s in NYC, where residents seized control of blighted vacant lots and converted them to community open space. As the city increasingly recognized the value of the gardens, they began to support them through granting permanent land tenure; helping with water systems, soil remediation, and procuring seeds; technical advice, and competitive grants programmes. It is at this point, when the balance shifts from local control and entrepreneurship to greater dependence on municipalities or other bodies, that community gardens become less “claimed spaces” and take on aspects of “invited spaces” (Gaventa, 2004). Whereas much of the participatory development and collaborative natural resources management literature focuses on invited spaces, or situations where government or more powerful NGOs invite local stakeholders to participate in management decisions (*e.g.*, Schusler *et al.*, 2003), civic ecology practices represent a merging of claimed and invited participation.

In a parallel to the distinctions between environmental activism and stewardship practice discussed earlier, Reid and Nikel (2008) review the literature on participation in EE, defined as opportunities to be actively involved in all aspects of solving environmental problems, and on participatory learning, which suggests that learning occurs through

engagement in behaviors and practices, often in cooperation with others. Garden Mosaics includes an environmental activism component through the youth Action Projects (see Textbox 1), as well as a focus on participation as learning situated in practice. Learning in Garden Mosaics occurs within the context of an ongoing natural resources stewardship practice; youth participants can be viewed as moving from peripheral to full participation in a community gardening community of practice (Rogoff *et al.*, 2003). Similar EE and science education programmes in which youth become engaged in stewardship communities of practice focused on enhancing local wetland habitats are described by Roth and Lee (2004).

In order for the participatory learning that occurs through Garden Mosaics to represent the self-organization attribute described by resilience systems scholars, we should be able to identify a social-ecological system level property emerging from the individual inquiry, stewardship, and civic activities. We have initial evidence from participant surveys and informal observations that elders who were interviewed by Garden Mosaics youth developed more positive ways of viewing youth in their community, and felt recognized by youth's interest in their expertise (Krasny, 2007). Greater connectedness among youth and adults can be viewed as a community-level property emerging from the interviewing, gardening, and other individual activities. Such social connectedness may lead to a number of outcomes that contribute to social-ecological system resilience, such as broadening the range of perspectives included in managing local resources, and the development of social networks that may mobilize knowledge for ecosystem management (*c.f.* Olsson *et al.*, 2004).

### **Conclusion: Towards a Social-Ecological Systems Resilience EE Research Agenda**

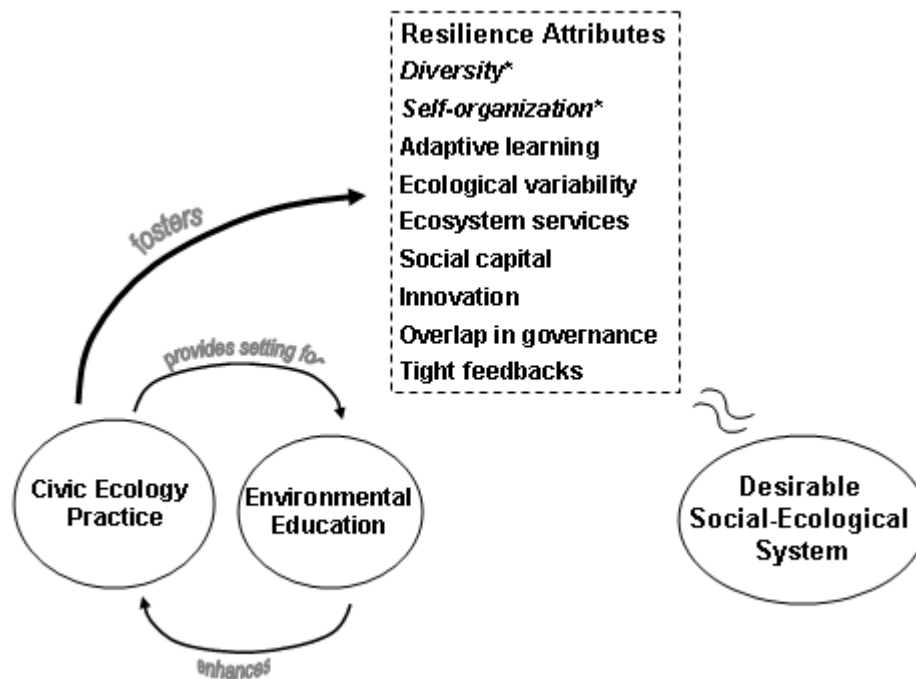
In this paper, we describe how civic ecology and related EE practices integrate two attributes of resilient social-ecological systems: diversity (biological and forms of knowledge) and self-organization (plantings leading to ecosystem services and participation leading to social connectedness). Although not within the scope of this paper, it is likely that EE contributes to additional resilience attributes, and thus one outcome of EE could be fostering resilience in urban social-ecological systems (Figure 1). Having proposed such an approach, we recognize two caveats. First, even though civic ecology and EE situated within civic ecology practice seem to have promise for integrating social and ecological outcomes in urban and other populated areas, they represent only one of many approaches to natural resources management and EE. Second, assumptions inherent to the resilience framework need to be critically examined rather than accepted at face value. For example, ethnic diversity is inversely correlated with measures of social capital in the USA (Putnam, 2007), yet both diversity and social capital are proposed as attributes of resilient social-ecological systems (Walker and Salt, 2006). Similarly, Thompson and Starzomski (2007) have questioned commonly accepted notions about the role of biological diversity in ecosystem functioning. The fact that concepts such as diversity and self-organisation developed within the ecological sciences have been broadly applied to the social sciences also creates confusion within the resilience literature. Thus, a critical discussion of the role diversity and self-organization in fostering resilience must address multiple issues having to do with vague definitions of

terms as well as contested uses of various forms of knowledge and of participatory approaches to development, natural resources management, and education.

In addition to more critically examining the diversity and self-organization attributes discussed in this paper, a resilience EE research programme would expand its analysis to include such attributes as adaptive learning, innovation, social capital, and ecosystem services (Walker and Salt, 2006). Some such research projects are currently underway. For example, Duffin *et al.* (2007) examined the impact of EE programmes in the USA on improving air quality, an important ecosystem service (*e.g.*, when youth advocate for a new school bus idling policy). Simon (2008) is conducting research to determine changes in social capital among NYC youth engaged in EE, and Kudryavtsev (2009) is investigating individual and ecosystem outcomes of EE programmes that engage youth in habitat restoration along the Bronx River in NYC.

In addition to a focus on more “linear” research approaches designed to determine the impact of civic ecology education and other forms of EE on resilience attributes, a systems perspective also suggests questions about feedbacks among EE and other components of a social-ecological system. For example, a series of positive feedback loops may transpire as people engaged in civic ecology practice realize individual outcomes (*e.g.*, sense of agency, feeling of connectedness to people and to nature) and become more active in such practices, thus contributing to greater social-ecological system resilience. Feedbacks may also occur between an EE programme and civic ecology practice, as youth learn from adults and then contribute to the adults’ work in restoring local habitats. By positing educational programmes, CE practices, and system level changes as a series of nested feedback loops, the resilience framework also suggests questions about how educational outcomes for individuals might be linked to outcomes for surrounding communities (*e.g.*, social capital, ecosystem services, biodiversity, (Krasny *et al.*, 2009). A research programme that examines a broader “ecology of EE” (Tidball and Krasny, 2009) would address these and similar questions about interrelationships among different system components.

**Figure 1. Hypothesized relationships of civic ecology practice, environmental education, and resilience of a desirable social-ecological system.** Civic ecology practices, such as community gardening, community forestry, and watershed restoration, foster multiple attributes of resilient social-ecological systems (*c.f.*, Folke *et al.*, 2002; Walker and Salt, 2006). Civic Ecology practices also provide a setting for EE programmes. EE programmes situated in civic ecology practices enhance those practices and thus further foster the resilience attributes characterizing desirable social-ecological systems.



\*Two resilience attributes that are discussed in this paper; additional ecological and social attributes of resilient social-ecological systems also may be fostered by civic ecology practice and EE, and are the subject of forthcoming papers.

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