Biocultural Restoration in an Urban Watershed
Onondaga Creek-Syracuse, New York

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Introduction and Literature Review

In 2004, the Society for Ecological Restoration International (SER) published a primer to measure the success of restoration projects. The measures of success focused on nine ecosystem attributes as guidelines. Successful restoration, by these criteria, is solely determined by ecological processes. The primer does acknowledge that restoration may be dependent upon long-term participation of local people but fails to go further. Human-centered attributes should be included in measurements for long-term restoration success. Cairns (2000) states that an essential consideration to the success of restoration projects is whether the goals are socially feasible. He defines social feasibility as the willingness of a society to commit enough resources to sustain restoration efforts over significant periods of time. Ecological restoration needs a societal commitment of support. Community members' involvement is crucial to long-term success and many restoration practitioners are coming to believe that biocultural restoration is the way to achieve this.

Those most affected by the degradation must have a vested interest in the system to ensure success and protection from further degradation (Cairns 2000). In order to do this on a community level, people need to be involved in all aspects, from planning to implementation of the restoration project. Restoration should not only pertain exclusively to scientists but be undertaken by communities (Havinga 1999). Cultivating more informed citizens fosters commitment to local environments and the community. Promoting community involvement can have implications beyond successful ecological restorations. It can affect personal feelings of empowerment, increase social connections and encourage connection to natural world.

In this project, we attempt to incorporate people into the restoration process through involvement with green infrastructure in an urban watershed. Our project begins with a literature review of biocultural restoration concepts and tools. Then we describe an applied component where we visited sites in a local sewershed for purposes of property microassessment for stormwater remediation. Finally, we provide sample designs and recommendations for selected properties based in part on our literature review.

Biocultural Restoration

Biocultural restoration is a process to integrate human values in ecological restoration to increase long-term restoration success. Often ecological restoration is needed in ecosystems that people have directly or indirectly impacted (SER 2004). By engaging people on a community level in restoration projects some of the detrimental human activities may be alleviated. Through the process of restoration, people will become educated on the local ecosystem and understand the direct connection between their actions and the surrounding environmental health. This direct connection will strengthen as the stakeholder continuously observes the work that he or she is contributing to. The developing vested interest from community members will increase the commitment to see the restoration completed (Shandas and Messer 2008).

Cairns (2000) believes that the best way to accomplish this is to reframe restoration in terms of how it can meet human needs rather than on reestablishing historical plant and animal communities. To this end, we can appeal to human self-interest by linking restoration efforts to maintaining quality of life, restoring and enhancing the ecosystem services provided by the environment, and avoiding the tremendous costs that would be incurred if we had to engineer those services.

Navigating Complex Social Issues

Multidimensional incentives should be employed to increase community participation in restoration projects. Monetary, equity or empowerment are all forms of incentives. Berkes

(2003) states that in community-based conservation equity and empowerment are often more important than monetary incentives. Monetary incentives can limit a person's view on realizing long-term values. If monetary incentives are depleted local conservation activities can cease (Songorwa 1999). People who understand the reason and purpose behind restoration can realize their vested interest or equity to the project. This can be ensured by making linkages between restoration and quality of life obvious on every scale (Geist and Galatowitsch 1999). Two key elements to making community-based conservation work are sharing of management power and responsibility, as opposed to token consultation and passive participation, and creating a context that encourages learning and stewardship and builds mutual trust (Berkes 2004). These two elements will build a sense of responsibility and empowerment among stakeholders.

Moran (2007) reiterates these principles. She believes that changing how we describe and measure restoration success in urban areas will help make restoration more relevant to residents. Traditionally, restoration metrics focus solely on ecological benefits, such as the number of restored "stream miles" or increased biodiversity. Instead, Moran suggests measuring the level of positive human impact a restoration project would generate, indicated, for example, by how much foot traffic the area would get or how many feet of stream would be made accessible through daylighting. Moran expresses the reciprocal link between ecological and biocultural restoration:

> If stream restoration proponents were to focus on the human dimensions of stream restoration—rather than the stream itself—restoration initiatives could have richer impacts that extend into the local community and beyond … [R]esearch conducted by environmental educators has established that people are positively influenced by having regular, ongoing connections with nature, even when it is in a degraded form. This can result in an increased level of environmental literacy, which is in turn associated with greater community involvement in environmental issues, suggesting that urban stream restoration projects can lead to several kinds of benefits. Thus, if proposed stream restorations were selected with some consideration of their public exposure—how many people would see the

> transformed waterway and in what context—the projects might begin having even broader impacts on their communities that those being carried out at present.

Moran believes that the challenge will be to transcend social difficulties to ensure that stream restoration can become re-centered on the connections between people and watersheds. Social scientists and social science perspectives could be used to facilitate relations between people and navigate difficult situations. A political ecology framework—which addresses environmental and ecological problems in their larger human context by looking at the way social, economic and political relationships shape patterns of resource use—can be used to help redirect our focus to the political aspects of ecological restoration and, in turn, the biocultural restoration necessary for success.

Social analysts have developed new ways of dealing with these complex social "problems" that defy traditional linear problem-solving methods, often termed "wicked problems" (Horn 2001; Allen and Gould 1986; Christensen 2009; Conklin 2005). Horn (2001) advocates using a "social mess map" to create an image of the thought processes and concerns of stakeholders and to show the connections between the different issues (Figure 1). By getting it all out on the table and creating a common ground, everyone can work to resolve the issues starting from the same point. The map also serves as a reference point as the problem-solving process proceeds and saves time by eliminating the need to continuously rehash the dynamics of a complex issue.

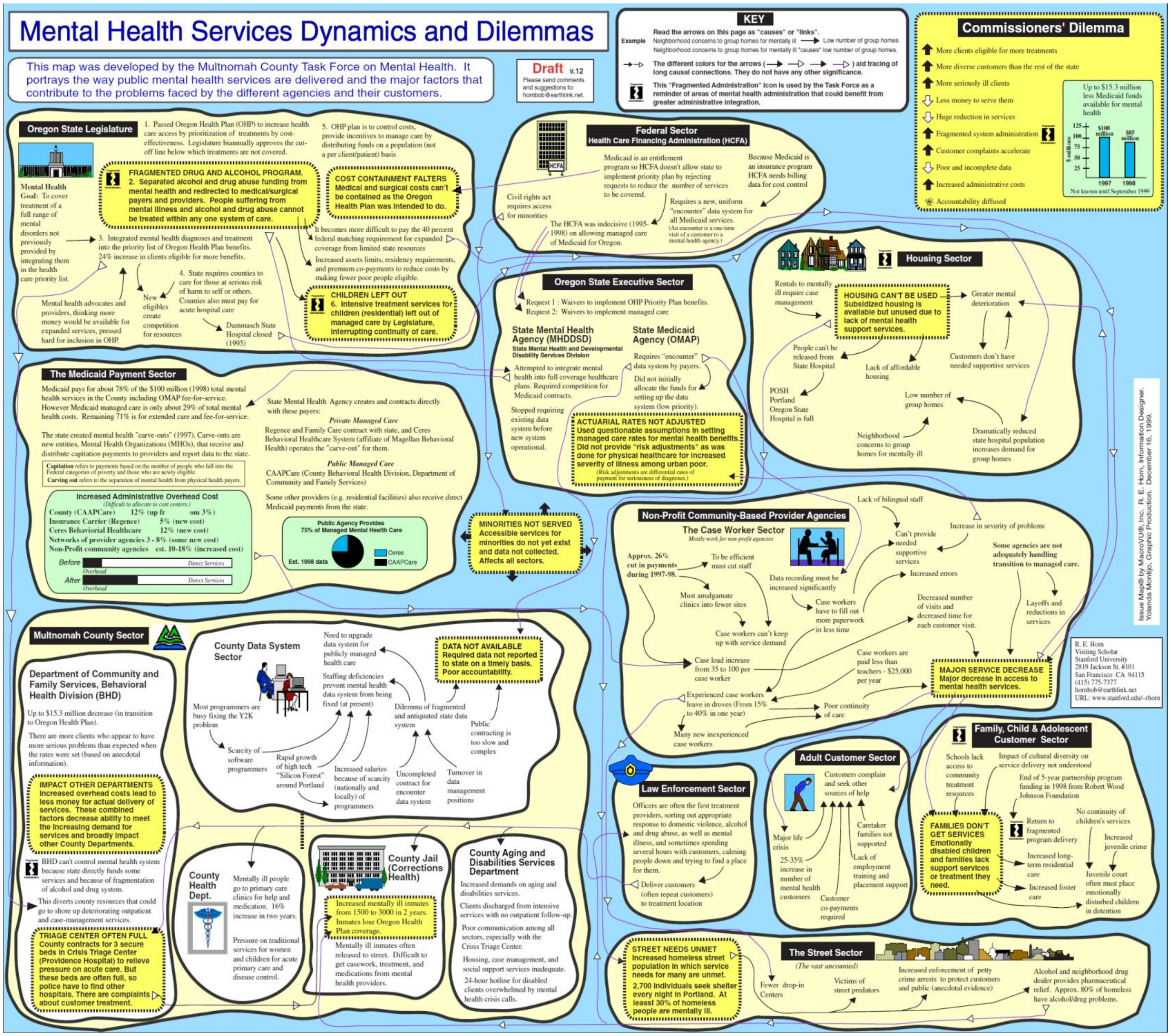

Figure 1. Example of a social mess map from Horn (2001).

Reciprocal Transformation of Volunteers and Environment

Ryan and Grese (2005) did studies of restoration volunteers that looked at how transforming urban areas through restoration has transformed their environmental attitudes and outlook and reconnected them with the natural world. They found that people decided to volunteer for many reasons, including helping the environment and feeling useful, taking tangible steps and meaningful action to improve their local areas, and having intimate contact with nature and learn about specific plants and animals.

According to Ryan and Grese, volunteer restoration and stewardship programs "give participants a chance to reflect, and reflecting about nature and its relationships to one's life may be the starting point in developing an environmental ethic." This is evident from their study of 148 volunteers, which looked at the relationship between volunteering and changes in environmental attitudes and behaviors. They found that 75 percent of the volunteers had developed a stronger interest in protecting local natural areas than before they started volunteering. Seventy-nine percent had a general increase in their appreciation for natural areas and 46 percent reported visiting them more frequently and feeling more at home in such settings—an important factor for many urban people who have had negative or limited interaction with "nature."

Working on the same project area for several seasons fosters a connection to place, and the volunteers indicated that their feelings of attachment extended beyond the areas they had restored to other local areas. Like Geist and Galatowitsch (1999), Ryan and Grese believe the act of "tending nature and watching it grow creates a powerful emotional bond that can energize volunteers into other environmental action."

Ryan and Grese recognize that ecological restoration can be controversial and present challenges to reconnecting people to urban natural areas, including differing perspectives on what is "natural," safe and healthy. For restoration to achieve maximum success, they list the following ideas for linking the restoration of urban natural areas to the larger social needs of residents:

- Planning projects according to the aesthetic and recreational desires of locals and involving them in the planning process

- Determining the characteristics of a place that locals already appreciate
- Preparing volunteers for the reality of restoration: it takes time and does not always go as planned
- Using the process of restoration to creatively engage volunteers and the public in new and different ways, including working with artists
- Incorporating memorable events such as potlucks or seasonal celebrations into the volunteer time and providing meaningful recognition of volunteers' work
- Incorporating opportunities to learn new things, monitor progress of their work, develop new techniques, create networks with other groups or neighborhoods, and problem-solve.

Community Involvement

Community-based restoration should engage the community through the whole process of the restoration. A restoration plan will be more successful on the community level if the needs and values of the community are understood. To better understand these needs, community representatives should be included in the beginning planning stage of the restoration. With different levels of knowledge, stakeholders can contribute diverse restoration ideas of varying scales to be implemented within their community. People's knowledge and perspectives within the community can help to build a more complete information base that scientific research cannot provide (Berkes et al. 2000). If community needs and values are not represented within the restoration project, the restoration will likely not receive adequate support to be sustained long term (Geist and Galatowitsch 1999).

As shown in a community-based conservation project in Tanzania, lack of supporting cooperation with the community and assuming community values contributed to the failure of the project (Songorwa 1999). In principle, community-based wildlife management or CWM is a participatory "bottom-up" approach to conservation. Community members are involved in problem identification, planning, implementation, monitoring, and evaluation. In reality, the bottom-up approach did not come to fruition. For numerous reasons, community members were not granted the appropriate authority and their rights did not increase within the program. They were not able to contribute as the plan dictated. The project assumed the communities in Tanzania valued wildlife and would have a vested interest in conservation. In reality, the majority of the community was not generally interested in wildlife conservation and initially agreed to be a part of the plan for socioeconomic reasons. The program did not fulfill the promised revenue from the conservation plan and actually increased existing problems to community members such as crop damage. The CWM did not reach its intended outcome of community-based conservation and actually influenced the initial community members who supported the project to reevaluate and oppose the project.

Figure 2. Community members planting trees in Portland Oregon through the Community Watershed Stewardship Program

The Portland Oregon Community Watershed Stewardship Program (CWSP) is a great example of community level storm-water management and watershed restoration. The program offers community support through project grants, educational workshops, technical assistance, watershed council organizational development and informational resource. Their success is attributed to the involvement of multiple stakeholders and experts in all aspects of the plan and allowing participants to define their own goals (Shandas and Messer 2008).

CWSP is designed to encourage citizens to undertake activities that would form partnerships in the community and use volunteers to affect change and improve watershed conditions at a neighborhood scale. CWSP also provides students and faculty with opportunities for education and research to allow an exchange of expertise and effort between the local university and government agency.

Involving stakeholders to be a part of the beginning process of a restoration project fostered a sense of ownership (Shandas and Messer 2008). In CWSP, community members helped to identify prominent issues and restoration projects within their community. This was a very different approach than traditional engineered restoration projects implemented by environmental agencies. For CWSP the experts' major roles were not in the actual restoration but more in education of understanding the multiple dimensions of watershed restoration (Shandas and Messer 2008). Community members were allowed to feel their own sense of empowerment while they became more informed citizens. The success of CWSP is shown through the numerous and diverse restoration projects that have been completed and the growing amount of community members wanting to participate.

Empowerment

. Community restoration is more than just the restoring of an ecosystem, it can also affect personal well being. "Participating in restoration is a healthy and empowering act in a world in which one can easily feel overwhelmed" (Havinga 1999). Community projects can create healthy social interactions that lead to a sharing of information and knowledge. It can give people a sense of purpose. As with the CWSP, one of the goals is to create relationships within the community. These relationships can foster communication. With an increased sense of empowerment and communication, community members might take action to address other issues such as making the community more safe and reducing crime (Westphal 2003). Social benefits from restoration projects such as empowerment are not always ensured. Practitioners need to be aware that cultivating empowerment is an active process. Westphal (2003) offers some recommendations practitioners should consider if social empowerment is an intended outcome:

Before the project:

- What are the benefits and goals that local residents identify as important?
- Do the needed benefits stem from having green areas or active involvement of a restoration plan?
- What level is the target population? Individual, community, or organization.
- Local resident motivation differs depending on what they are most concerned by.
- Empowerment is a developmental process.

During the project:

- Process is key. Foster open and inclusive decision making in greening projects.
- Watch out for "empowered but not empowering" local participants, particularly those who dominate a project.

After the project:

- Practitioners should take their assessments of the impacts on the neighborhood with a grain of salt, recognizing that they might not see all the important interactions among project participants and non-participants.
- Networking with other good, non-greening organization can further the empowerment potential from green projects.
- Whether empowerment outcomes from active involvement come to fruition or not, greening projects may also confer or enhance benefits from living in a green environment.
- Recognize that urban forestry is a part of the solution but cannot transform a distressed neighborhood alone.

Ecological Art

Figure 3. “I Like America and America Likes Me,” 1974. Joseph Beuys, a pioneer ecological performance artist, spent three days with a coyote in Rene Block Gallery in New York City. Mr. Beuys is wrapped in felt and with the cane.

Starting with Joseph Beuys’s works in the 1960s, shown in Figure 3, ecological art work has pushed people to explore connections between natural systems and can expand the conception of art to challenge the social, economic, and political ideas of Western society (Blandy et al. 1998). Combining restoration and art heightens awareness of human relationships to the local ecological processes. Art is created for human engagement. Community understanding of local impacts to the ecosystem is an important step to the success of a restoration project. Including eco-art within a community restoration project will increase awareness as well as sense of pride within the community. The process of creating and observing ecological artworks creates a space for people to experiment with ideas and their relationship to the natural world. Eco-art can be created and exhibited at different levels of society. Starting with elementary schools through college and into the community, the combination of ecosystem education and art can influence everyone. Blandy et al. (1998) believe experiences that engage students in viewing the world as ecosystems encourage an awareness of the importance of environment and their relationship to it. The process of creating art that has functional applications in restoring local ecosystem degradation links people's choices to its effect in the natural world. People can experience how their actions can be part of the solution and not contributing to the problem.

Outdoor ecological art can include pieces that push boundaries, beautify the landscape, and have a functional value in restoration projects. Green infrastructure can be considered a form of ecological art. The process of creating a rain garden, choosing color and texture, and understanding how each plant will contribute to the overall composition is an act of art. Rain gardens are perfect opportunities for watershed education, as well as providing an aesthetic value. Green infrastructure can increase people's vested interest in their community.

Jordan (1994; Friederici 2004) also advocates using the creativity engendered in ecological restoration as a form of biocultural restoration. The essential biocultural connection to place can be established by purposefully developing restoration as an artistic, creative process that actively engages people with the environment. Restoration is a way for people to learn about the natural environment in which they live and the ways they have influenced it, both good and bad. Jordan sees restoration as a ritual that mediates this relationship between humans and the environment, transforming the idea of nature as a commodity and humans as consumers/visitors into a mutually beneficial relationship. The process of restoration engages a greater portion of human interest and skills than passive activities such as hiking or birding. By interacting creatively and actively with nature through restoration, "the range of experiences available in the landscape increases dramatically," and restoration will appeal to more people and on different levels.

Bioregionalism and Geographic Connections

A look at the fields of geography and bioregionalism—a place-based activist movement—may also provide some useful tools for biocultural and ecological restoration. Bioregionalists promote "reinhabiting" the area you call home by learning about the broader natural systems, such as watersheds, that contribute to the local environment (Parsons 1985). Bioregionalism promotes a geographically based "terrain of consciousness" and action that encourages communities to learn to be part of their own particular place systems rather than just being consumers (McTaggart 1993). Bioregionalists believe we should make life and consumer choices based on the effects they will have on the local community and the environment that supports it. In the words of activist John Johnson (2002):

> Give yourself to the land, not abstract notions of the Earth or the wild, but to real places, with real live plants, bugs, animals and people that you interact with, serve, teach and learn from. Commit yourself to home, land and community. Know where you live. Sink roots, get to know people, learn and know the flora and fauna of your place. Ask the fun questions: Where does the water go and where does it come from? What is possible in your home—gardens, restoration, wildcrafting, resistance? What is the natural and humyn history and herstory of your place? Fall in Love. Defend what you love, what you are a part of and what is a part of you. Practice resurrection … [of] the Land!.

One tool for mapping this terrain of consciousness and action is using the Green Map System pioneered by Wendy Brawer (www.greenmap.org). The Green Mappers have worked to develop internationally recognizable symbols for mapping local green initiatives such as bike lanes and rooftop gardens, as well as sources of environmental degradation. School groups, organizations and communities from around the world have used the system to create images of the work people have done in their communities to improve the environment, as well as highlighting areas that need restoration.

By creating a map that can be shared online or on paper, people can demonstrate how they are taking local action for the environment and share the knowledge they have gained with others. This method generates a means of helping people to see their communities in different ways and guide them in acting on this new information. It also provides individuals with a visual sense of community and support by displaying the existence of other people who share their concerns and interests.

Figure 4 is a model of how the ideas and tools described above can be used to increasingly transform the ecological restoration process to include human needs and biocultural restoration. According to many of the authors reviewed here, such steps are necessary to improve the chances for success of restoration projects and biodiversity.

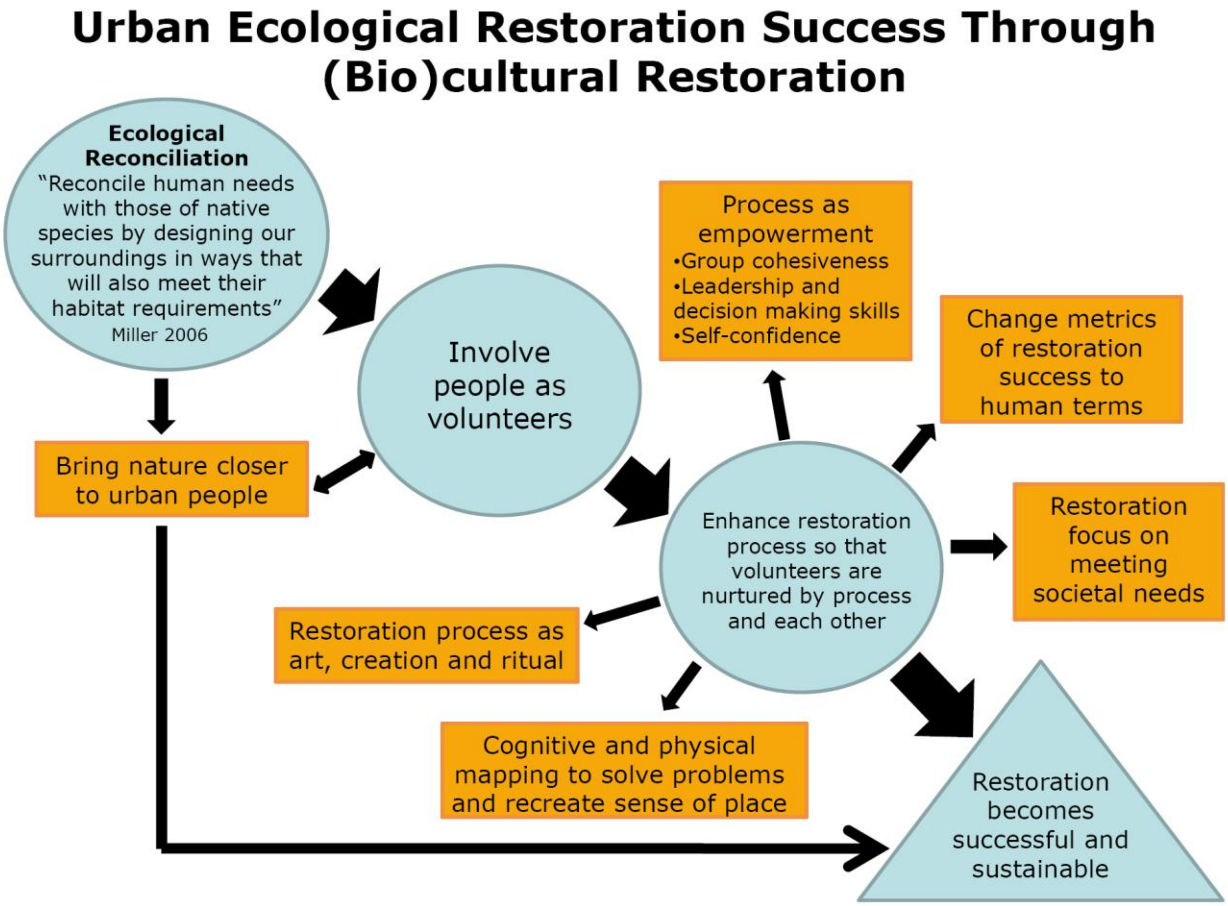

Figure 4. This conceptual model provides a synthesis of concepts and actions that can be used to transform the ecological restoration process from being solely science-based to include biocultural restoration and human needs and improve the sustainability and success of projects.

CASE STUDY: GREEN INFRASTRUCTURE FOR CSO ABATEMENT IN SYRACUSE, NY

Syracuse, NY (population approximately 150,000) is a post-industrial upstate city that in its heyday was an important producer of salt and a central stop on the Erie Canal. Like many northeastern cities it suffered losses to downtown areas as people fled to the suburbs, marring outlying countryside with unchecked suburban sprawl.

Our assigned task was to take the current *Conceptual Revitalization Plan* for Onondaga Creek (OCWG) and help bring it to reality by creating designs for parts of the Creek corridor. Onondaga Creek flows through the heart of Syracuse, becoming an urban stream for the final 14.5 kilometers of its course (Figure 5). From its headwaters along the Valley Heads Moraine near Tully, New York, to its mouth along the shores of Onondaga Lake, Onondaga Creek flows about 43.5 kilometers.

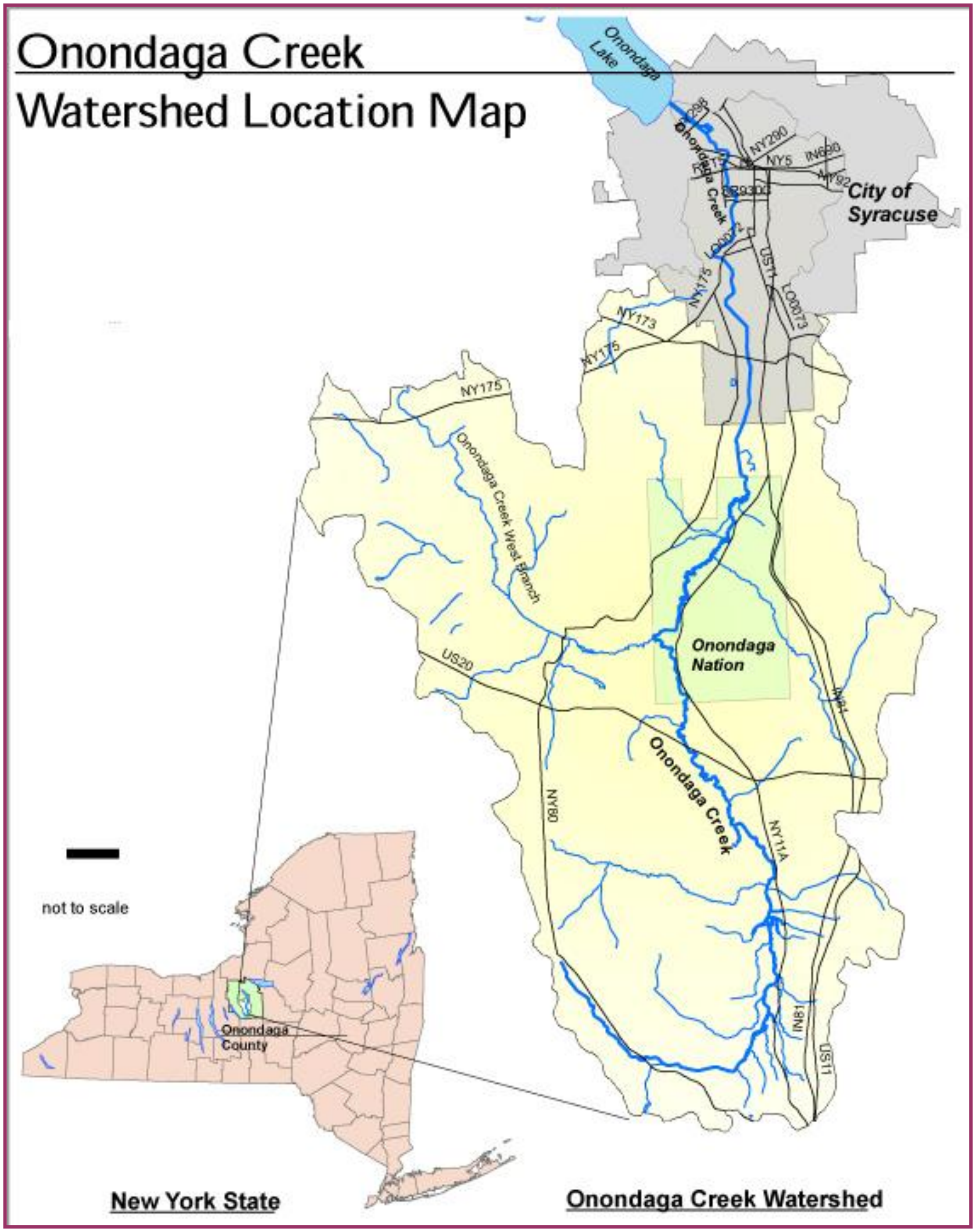

Figure 5. Onondaga Creek watershed. Map courtesy of Onondaga Environmental Institute (OEI).

Historically, Onondaga Creek supported Atlantic salmon (*Salmo salar* Linnaeus) and American eel (*Anguilla rostrata* LeSueur); it once meandered through floodplain forests, cedar swamps and, near its mouth at Onondaga Lake, inland salt marshes. Black ash (*Fraxinus nigra*) once timbered the swamp near the mouth of the creek, in an area currently covered by Carousel Mall. Onondaga Creek has been channelized, deepened, dammed, and nearly all these associated wetlands have been filled in to build the streets, buildings, parking lots and industrial areas of the city of Syracuse.

Long before the white man set foot in this region, the Onondaga people cherished the Creek and harvested from it an abundance of fish, especially salmon and eel. The Onondagas were forced out and their lands fraudulently acquired by New York State (R. Ketcham, pers. comm.). The Onondaga Nation recently filed a land rights action which addresses many past grievances and demands that water quality be restored to Onondaga Creek and Onondaga Lake, the birthplace of the Haudenosaunee confederacy (Lane and Heath 2007).

History: Using streams as sewers

In the late nineteenth and early twentieth century, many cities constructed sewer systems to centralize treatment of wastes and replace privies and urban septic systems with sanitary sewers. In doing so they aimed to reduce disease and odors caused by sewage contamination of water and soil. Fecal contaminated waters contain pathogenic bacteria responsible for spread of disease upon swimming or other contact. A cholera epidemic reportedly occurred in the Syracuse area in 1832 (McKellops 1832), and other diseases such as typhoid were possible (J.C. Savage, pers. comm.).

These early sewer systems combined stormwater runoff from streets and domestic sewage in the same pipes. Unfortunately during heavy storms the volume of water could exceed capacity (many of the pipes were no more than 12-18” in diameter) and thus present the hazard of backing up and flooding basements and streets. To prevent sewer back up, the pipes were designed with a weir (relief structure) that allows overflow to streams.

For over a century Onondaga Creek has been used in this way as an open sewer for conveyance of wastes. The last beach on Onondaga Lake closed in 1940 due to concerns associated with sewage contamination (OLCC 2001). The sewage was delivered to the lake by tributaries, especially Onondaga Creek, which had 42 CSOs at the time. Other problems with sewage include increased nutrient levels, which can lead to eutrophication of lakes and streams, with harmful effects on aquatic food webs.

Public health standards for indicator bacteria are routinely violated throughout the southern half of Onondaga Lake during storm events. During summer months, there are about 18 storms that can lead to 54 days of violations in Onondaga Lake (OLCC 2001). This state of things obviously presents major water quality problems. Nonetheless, before 1972 these overflows were considered by cities to be necessary, inevitable, and lawful.

1972: Clean Water Act

Since 1972, building a combined sewer system is considered illegal. The federal Clean Water Act (CWA) also warned cities that their current CSO systems could be in violation of CWA standards. In Syracuse, about 42 percent of sewer lines are separated; the rest are combined (SOPCA 1972). The city of Syracuse and Onondaga County share responsibility for the combined sewer system. The city builds and maintains the smaller sewer lines that connect to properties, while the county maintains the large sewer trunk lines which convey the city’s sewage to the county’s METROpolitan sewage treatment plant (Baptiste and Lane 2009).

1988: Amended Consent Judgment

In 1988, the Atlantic States Legal Foundation (ASLF) sued Onondaga County for violations of CWA from discharges from METRO and from 63 CSOs along trunk sewer lines (Baptiste and Lane 2009). ASLF was later joined in its suit by the New York State Department of Environmental Conservation (DEC). According to the lawsuit these discharges were polluting Onondaga Lake and its tributaries.

The federal government mandated that Onondaga County develop a plan to address the CSO problem. Ten years later, ASLF and NYS DEC agreed to the county's plan, which took form as the Amended Consent Judgment or ACJ. The original ACJ plan called for five regional treatment facilities (RTFs) in neighborhoods along Syracuse's creeks.

Environmental Justice: Midland Case Study

Two serious flaws marred the county's solutions to CSOs in the ACJ. First were issues of inequity and racism. One of the largest treatment facilities was sited on Midland Ave in a low-income, largely African American neighborhood along Onondaga Creek (Baptiste and Lane 2009). In 1999 Onondaga County announced that it would evict 35 African American families at the proposed site. This was not the first time this neighborhood had faced evictions or other intrusive mandates supposedly necessary for overall public good. South side residents have faced cumulative effects, for example, from various industries and facilities already sited on the South Side, such as Coyne Laundry and the Centro Bus garage (POC members, pers. comm.).

In 2000, neighbors formed the Partnership for Onondaga Creek (POC). This grassroots group, underfunded but determined, urged the county to "do the right thing" and not force the African American community to bear the burden of yet another public works project. POC revealed gross inequities between the "footprints" of sewage treatment facilities in affluent

(Franklin Square) communities versus low-income ones. They (along with Syracuse University's Public Interest Law Firm) filed a civil rights claim with the US EPA against Onondaga County and NYS DEC.

Besides its racist bent, the second problem with the county's plan was the antiquated technology proposed to address the CSO problem. POC's work revealed that the swirler-chlorination technology the county hoped to implement in its RTFs, while it killed bacteria (and therefore met some minimum standards of the ACJ), sent pollutants into Onondaga Creek in the form of byproducts of the dechlorination process. Over the next eight years, by means of hard work, perseverance, savvy, and key alliances, the POC changed the face of sewage treatment as practiced by Onondaga County from gray to greener, as discussed below.

The Greening of CSO Abatement in Syracuse

Thanks largely to POC's work, Onondaga County is currently moving to complement gray methods of CSO abatement with green technologies. Gray methods, which would still treat 95 percent of stormwater runoff (K Dodson, pers. comm.), include sewer separation, in-line storage conveyance, off-line storage tanks and the swirler-chlorine technology used by RTFs. Green methods, in contrast, exemplify ecological engineering principles by mimicking ways rainwater is "treated" in natural ecosystems such as forests. With green infrastructure (GI), stormwater is absorbed on site and kept out of sewers in the first place.

Historically, of course, green infrastructure was the rule for Onondaga Creek. The draining and filling of wetlands, however, and later paving over of much of the land area with impervious features, helped to change the hydrology of Onondaga Creek's urban watershed from one dominated by groundwater to one of surface waters efficiently piped to local waterways such as the Creek. *The historical system of springs, wetlands and tributaries has largely been* *converted to a piped storm sewer network designed for efficiency of water removal.* For this reason, renaturalizing hydrology (as shown in Figure 6) is critical, not only to prevent sewer overflows and enhance water quality to meet CWA standards, but to Onondaga Creek function and to meeting the ecological goals of the Revitalization Plan. The importance of re-naturalizing hydrological cycling in urban areas is discussed below.

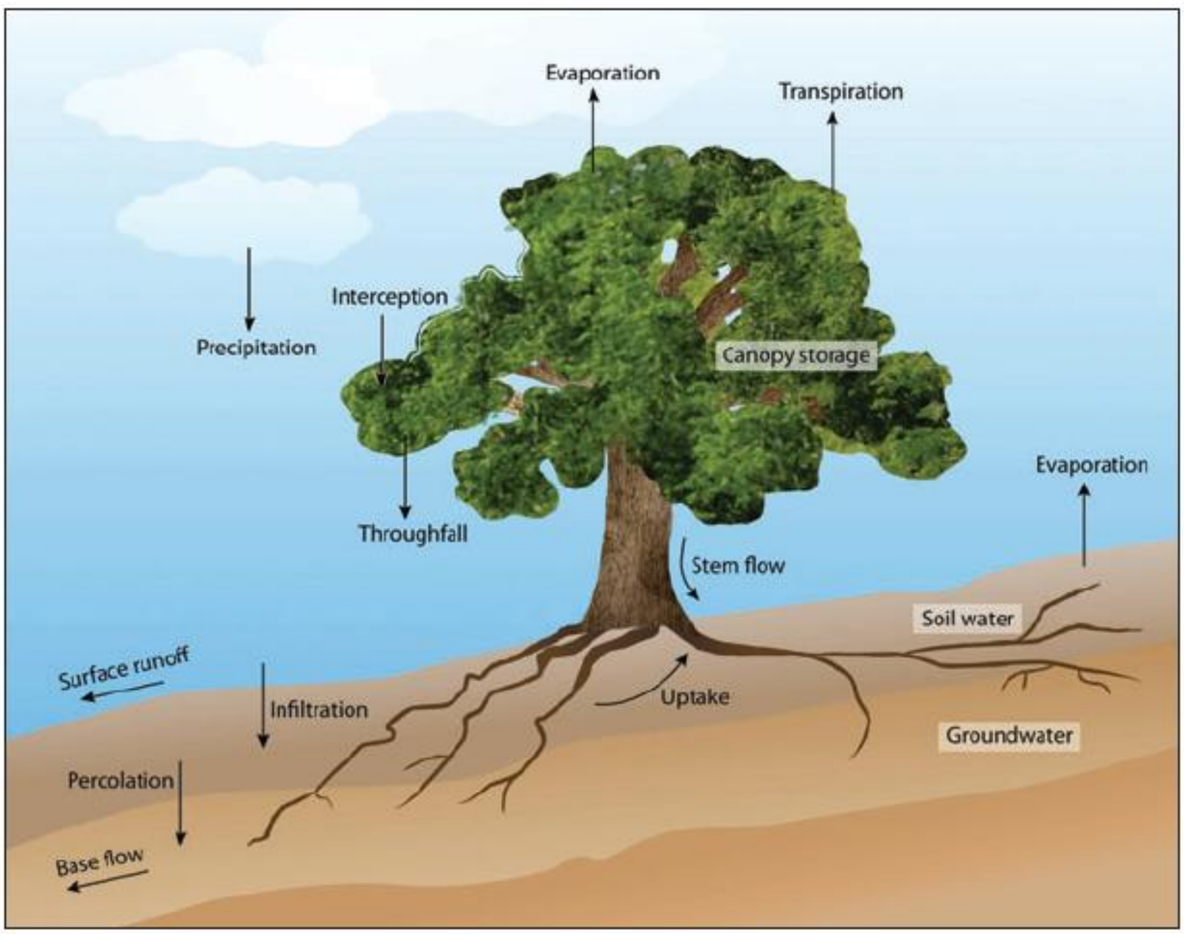

Figure 6. Water balance of a forested ecosystem. Precipitation that is intercepted by the canopy may be evaporated to the atmosphere (interception loss), absorbed by the canopy (storage), channeled downward along branches and stems (stemflow), dripped to the ground (throughfall) (Roth et al. 2007).

Is GI "ecological restoration"?

As defined by the Society for Ecological Restoration International, ecological restoration is an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity, and sustainability (SER 2004). By this definition, adding rain barrels or trees to the urban landscape may seem little more than minor domestic or infrastructural changes, not focused at all on "ecosystem recovery." In fact, when the issue of GI was raised in a recent seminar, one ESF faculty member responded that planting a tree in your backyard is not ecological restoration.

We would argue that we have to remember the urban context, and that "baby steps" (A. Lane, pers. comm.) may accrue to restoring ecosystem function in the long run. For urban streams, as discussed above, reducing stormwater runoff and flashy flows from storm sewers and impervious surfaces is often considered *the* critical initial step in restoring urban streams (Brown 2000). The steps that follow—such as channel modifications and addition of native plants—cannot take hold without first dampening the typical storm hydrograph for an urban stream. That "flashy" hydrograph pattern must usually be addressed at the watershed scale.

One of the dominant features of urban areas is reduction in density and diversity of plants, as natural plant communities are replaced by impervious surface cover (ISC). ISC includes roads, parking lots, roofs, sidewalks, compacted soils—features typical of today's cities designed for transportation via private automobiles. Urban landscaping is often dominated by lawns that, while not strictly impervious, lack the surface area and water storage capacity functions of a forest. However, there is no intrinsic reason why much of that impervious surface could not be reduced via GI, including urban forests as well as tree planting on individual properties.

Once the process begins, communities can begin to realize multiple, ecological benefits of GI (Figure 7), especially if a policy of native plant use is followed from the start. There are plenty of native plant alternatives and no reason to resort to non-natives, as promoted by some forestry publications. Such ecosystem services include provision of pollinator plants, habitat corridors, microclimate modifications, urban biodiversity and improvements in air quality. Collectively, one "habitat island" yard at a time, some degree of "ecosystem recovery" can accrue, especially if accompanied and encouraged by education. Neighborhood benefits can include increased opportunities for recreation and spiritual uplift, as well as sense of place.

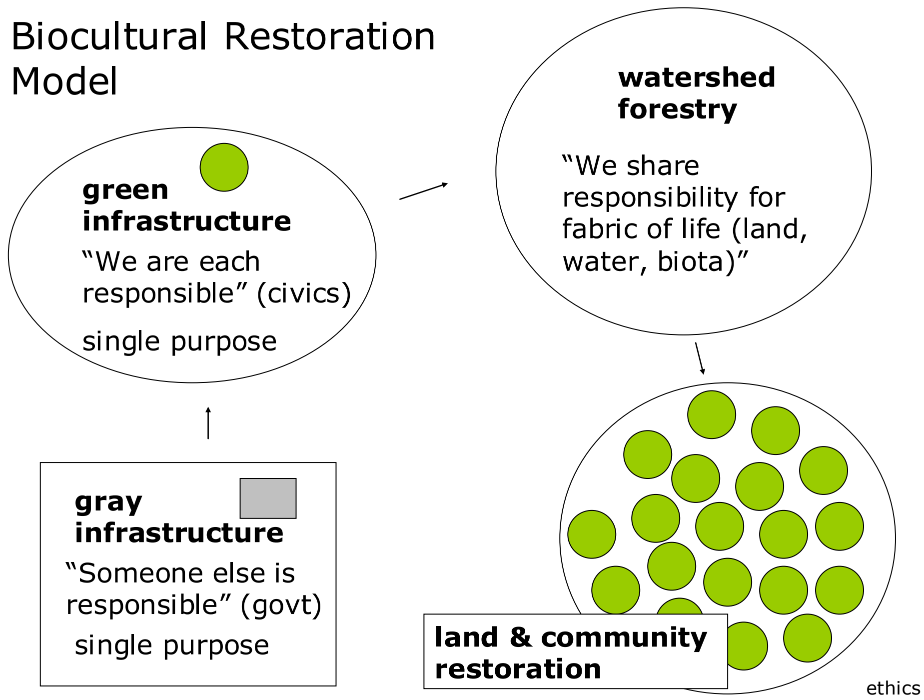

Figure 7. Biocultural restoration model for green infrastructure in an urban area: how people can connect to place beginning with stormwater awareness, and how ecological restoration can proceed from green infrastructure.

Sewer separation: the solution to the CSO problem?

Sewer separation, a "gray" technique whereby storm and domestic waters travel in separate pipes, might seem the logical solution to the combined sewer problem. This remedy is, however, flawed and actually perpetuates problems of gray infrastructure. First, with sewer separation, storm water goes directly into the Creek, bypassing any kind of wastewater treatment.

Storm water contains many pollutants such as heavy metals (e.g. from car brake linings), road salt, pet waste, oils (hydrocarbons), dust, as well as fertilizers and pesticides picked up as rain water flows over the ground surface (Paul and Meyer 2001).

Another problem is volume. Even if stormwater were pristine and drinkable, its sheer volume presents a major hazard to urban streams during storm events. Not surprisingly, hydrology has been cited as *the* major abiotic factor in restoring urban streams and their riparian communities as well (Walsh et al. 2005b, Riley 1998, Robertson and Augsberger 1999). The "urban stream syndrome" is driven primarily by disruption of natural water cycling in cities—in particular, via stormwater runoff from impervious surfaces delivered through pipes and sealed drains, rather than via infiltration and groundwater passage through soil (Walsh et al. 2005b, Brown 2000). In other words, something as apparently laudable as sewer separation can exacerbate THE driving factor in the degradation of urban streams.

Black (2005) conducted a thesis study to determine the effects of sewer separation on restoration plans for Onondaga Creek. She looked at outfall hydrographs from CSO 050 to compare separated from unseparated sewers in terms of peak magnitude, volume, and duration. She found that the separation process, whereby a combined sewer system is separated into a distinct storm and sanitary system, significantly increases output from the watershed. How the increase in output affects Onondaga Creek depends on scale. The larger the river and larger the flow, the smaller the impact will be on the receiving body of water.

Green Infrastructure: Let natural processes perform essential services

The final problem with sewer separation alone is the problem with all gray infrastructure at a time when we need to move towards green ones. Large regional storage facilities, high capacity pipelines and treatment facilities add nothing to the civic life of a community, and they often involve disruptive, costly construction (as experienced with the Midland RTF in Syracuse). They provide no new habitat or any value added to the ecosystem (Ferguson et al. 2001). They represent single-purpose solutions, where stormwater is seen as a problem and not a resource. Upstream sources would still be generating the same amount of runoff and pollutants.

They are also, arguably, not sustainable. As fossil fuels (e.g. oil) decline, natural energy flows must assume a greater importance. That is, in an energy-scarce future, services from natural ecosystems will assume relatively greater importance in supporting the human economy (Day et al. 2009). Ecosystem services, freely available natural processes, can work for the benefit of the watershed. These services can actually *a*ppreciate, not *de*preciate, with time (unlike gray methods which are inherently designed to *resist* natural processes such as growth and decay of vegetation). Vegetated soils absorb rainwater, and the chemical and microbial processes of the soil capture and degrade many pollutants (Ferguson et al. 2001).

Gray infrastructure projects proceed from the same mindset that once labeled Onondaga Creek as a “nuisance” and thinks urban streams are best kept underground in culverts. Keeping rain on the surface, in contrast, gives it the chance to feed streams, to infiltrate into soils and recharge groundwater, and water plants, thus supporting habitat and reducing the “flashy” flows that are the bane of urban streams.

Green Infrastructure Alternatives to Midland CSO Conveyance

Phase III of Onondaga County’s original plan for CSO abatement included construction of a pipeline, some of it 12 feet (3.66 meters) in diameter. This pipe would convey upstream CSOs to the Midland RTF for storage or chlorinated treatment. Pipeline costs were estimated at $57 million (POC 2008). POC presented green alternatives to the pipeline to the DEC in June 2008. They cited both the pipeline’s cost, as well as the continued issues of equity in terms of the construction effects of such a huge trunk line. The pipeline was planned to go right along Onondaga Creek from Newell Street to the Midland RTF. Placement of such massive infrastructure along the "banks" of Onondaga Creek in Kirk Park, for example, would nearly eliminate any chances for modifications of channel morphology such as those suggested by Dekoskie (2004).

The alternatives to the pipeline depend heavily on green infrastructure, especially in sewersheds connected to CSOs 052, 060, and 077 (Figure 8). Treating stormwater in these areas is critical to reducing sewage overflows, since these waters were originally supposed to travel, via the trunk line, to the Midland RTF for treatment. Instead of the trunk line, current plan is to reduce storm water flows at the source.

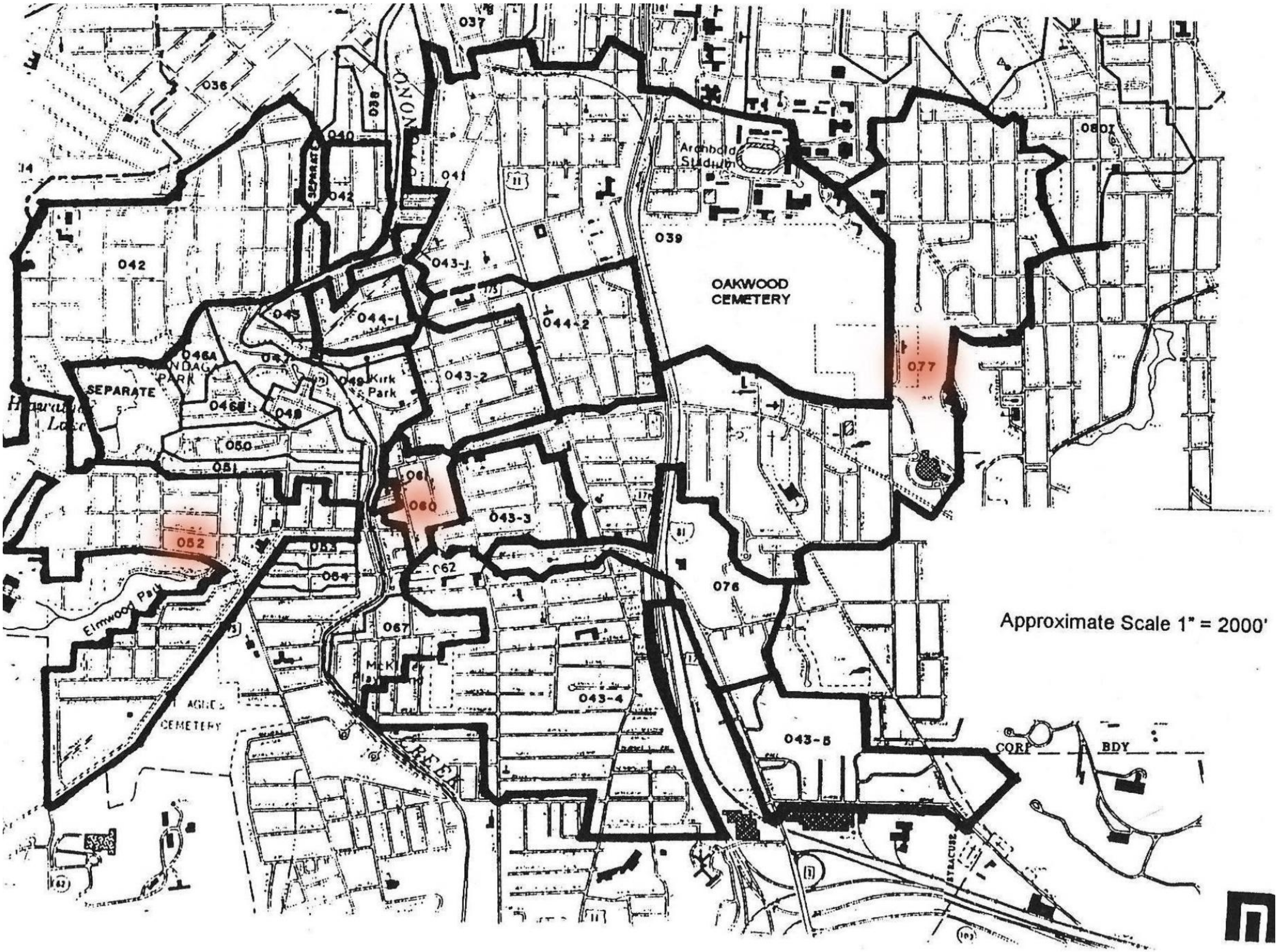

Figure 8. Sewersheds of Onondaga Creek. Source: Baptiste and Lane 2009.

What's Needed: Citizen Participation

This shift from gray to green depends on a concomitant shift in minds and hearts of residents, especially property owners. We've become passive, expecting large public works projects to handle our wastes, whether it's what we flush down the toilet, pour down the storm drain, or put out at the curb. Some government entity will take care of it. What is now required of us, is that we take responsibility for our own contribution to stormwater, whether through rain barrel, rain garden, cistern or adding trees. If every household assumes this responsibility, the cumulative effects on stormwater volume would be tremendous.

In October 2008, a survey was conducted of residents of these key sewersheds (i.e., those areas whose stormwater would be captured by the pipeline going to the Midland Plant). The survey aimed to gather opinions about the stormwater problem and to assess residents' response to GI methods (Baptiste and Lane 2009). The survey focused on sewersheds 052 and 077 (Figure 8), due to their size and relative contribution to the stormwater system.

Survey results showed residents were quite receptive to GI methods (particularly rain barrels, rain gardens and trees), especially if financial incentives are provided, e.g. in the form of subsidies, cost sharing, or provision for free.

METHODS: SEWERSHED PROPERTIES MICROASSESSMENT

Our group's task, developed in consult with Aggie Lane and others, was to pick up from where the survey left off by using the following methods:

1. "Walk the sewershed"—House by house property microassessment for runoff potential and the best GI methods to address site-specific issues.

2. Where possible, find property owners willing to invest in GI and perhaps become a model property for their street or block.

3. Investigate potential for GI implementation at institutional properties, especially schools.

4. Continue to educate people about stormwater runoff and green infrastructure.

Our intention was to provide data of value to those at the county level implementing green infrastructure. We focused on Sewershed 077 since GI in this area is crucial to replace the capacity of the giant trunk line, as previously discussed. Within 077, we focused on private homes, rather than rentals, since we assumed private home owners would be more in a position to install GI. The private homes are concentrated in two areas:

1. Near the water towers east of Comstock Ave (including streets such as Berkeley, upper Ackerman; near Ed Smith school)

2. Neighborhood between E. Colvin St and Vincent St (including Vincent Street), which is also privately owned residential.

RESULTS

Residential

Upper Ackerman

Homes here are privately owned with a few rentals mixed in. In general, the yards are well vegetated. Homes on the west side of street tend to have steep slopes down to street and this would be a key area for remediation, especially in cases (such as 1048) where vegetation on the incline is scant. Most houses here have gutters, which would facilitate GI installations (Table 1).

Table 1. Property microassessment for upper Ackerman Ave.

Land parcel number	Address	Assessment (runoff sources, etc)	Remediation	Comments	Homeowner receptivity
1	121 Windsor	has gutters	rain barrel at gutters, strip rain garden for driveway OR porous strip at end of driveway	relatively affluent area, generally well vegetated, well kept lawns. One home in area has visible blue rain barrel; could be model property	not home
2	120 Windsor	runoff sources are roof, driveway	add tree to front yard, also rain barrel		not home
3	1050 Ackerman	gutters only on N side of house; nice veg in front of house along steep slope down to sidewalk. No veg from sidewalk to road (steep)	Add perennial (woody?) plants to strip, sidewalk to road; gutters around entire roof. For shared driveway (see comments), treat indent that is acting as a channel directing water to storm drain, perhaps by adding a rain garden strip here if snow removal operations would allow (e.g., herbaceous perennials). Could also add a porous strip to end of driveway to capture runoff. Add plants to open grassy area along Broad, which currently has just one tree (conifer).	upper Ackerman - driveway behind homes drains to storm drain on Broad; shared by several houses on W side of street (e.g. 1050 Ack)	not home
4	119 Broad (corner of Ackerman and Broad)	gutters directed to grassy, steep slope that flows to Broad	2 rain barrels to treat water from gutters	this house shares driveway mentioned above; remediation as for 1050 Ack	Low; "I'm very green already. Thank you anyway."
5	1054 Ackerman		See remediation for shared drive above.		Homeowner is receptive, but moving out soon
6	1052 Ackerman		gutters (direct toward existing vegetation); shrubs in front on steep slope towards sidewalk		not home
7	1048 Ackerman	no gutters, part of front of house (steep slope) poorly vegetated; garlic mustard basal leaves dominate	add shade tolerant understory plants to poorly vegetated area; maybe also leaf litter or compost; add gutters		not home
8	1040 Ackerman	steep slope to road, no gutters; runoff sources are steeply pitched lawn and roof	rain garden strip in front at base of slope near sidewalk - add plants to area from walkway to road		not home

9	1026 Ackerman	gutters, well vegetated in front; several inv. plant spp.	remove invasives and replace with native plants over time		not home
10	102 Terrace (corner of Ackerman and Terrace)	has gutters, lots of plants, well vegetated, colorful door	rain barrel at gutters	numbers 10 & 11 may be artists, so might be amenable to artistic solutions	not home
11	1015 Ackerman	sloped away from street (so runoff flows towards backyard); interesting head on porch; well vegetated, has gutters	rain barrel		not home
12	1049 Ackerman	has gutters, tree, vegetation out front; sources are roof	rain barrel		
13	1053 Ackerman	has gutters, large tree; driveway drains directly in storm drain on street	rain barrel, porous strip at end of driveway		not home
14	1061 Ackerman	has gutters draining into mulched garden (see photo)	rain barrel on S side of house and at side of former garage (soil is thin so runoff high; owner added hostas and other plants to try to catch the runoff). Sidewalk along Broad slopes steeply and could use strip garden or trees designed to capture runoff; 4 car garage and area of impervious surface on drive way (facing Broad)	owner has installed dry wells to help capture some of the runoff from roof	High; very receptive; willing to install rain barrels; know about the rain barrel on Berkeley (see #1 entry above)
15					
16					

Vincent Street

Vincent Street is a residential street about two-tenths of a mile long in the Outer Comstock neighborhood. This street has 20 residential homes, all of which we assessed in order to make recommendations on potential green infrastructure for stormwater abatement on a home by home basis. Because the precise measurement of the dimensions of each house was beyond the scope of this paper, an average home size for this street was estimated at 25' by 30', or 750 square feet. This estimate is representative of the area. This approximate size was used to determine the runoff (in gallons) from a rooftop during a ½" storm event. We also used the average annual precipitation of 40" for Syracuse, NY, to determine the yearly runoff from each home. All properties slope toward the street, which has a total of eight storm drains present. The results of the assessments are shown in Table 2.

Table 2. Sewershed properties microassessment for outer Comstock area, Vincent Street.

Land Parcel	Address	Gutters	Downspouts	Assessment	Suitable Infrastructure
1	340	Yes	Driveway	Highly vegetated property, large trees present	2 Rain barrels
2	336	Yes	Driveway/Lawn	Highly vegetated property, large trees present	2 Rain barrels
3	330	Yes	Planting Bed	Highly vegetated property,	2 rain barrels
4	295	Yes	Lawn	Small property, few small trees	2 rain barrels
5	324	Yes	Lawn	Some vegetation, large trees in back. Lawn→ storm drain	1 barrel, neighbor's garden?
6	314	No	---*	Open lot adjacent, to house, drains to storm drain in front. Needs Gutters!	Large rain garden, space for neighbor's runoff too
7	306	Yes	Driveway	Gutter only 2 ft long, needs new gutters.	2 rain barrels
8	187	No	---	1 large tree, storm drain in on property	Garden in back
9	300	Yes	Driveway	Little vegetation	2 rain barrels
10	242	No	---	Some vegetation	2 rain barrels
11	236	Yes	Driveway/Lawn	Very little vegetation	2 rain barrels
12	237	No	---	Highly vegetated property, many large trees	2 rain barrels
13	230	Yes	Driveway	No vegetation	Large garden

14	229	Yes	Driveway	Highly vegetated property, many large trees	2 rain barrels
15	222	No	---	Some vegetation, storm drain in front	Small garden
16	218	Yes	Driveway/ Planting Bed	No yard, no vegetation	2 rain barrels for driveway
17	204	Yes	Planting Bed	Great downspout placement!	1 rain barrel
18	200	No	---	Little vegetation	1 barrel and garden in back
19	139	No	---	Very little vegetation, storm drain in front	Large garden
20	296	No	---	Large trees in front, storm drain in front	1 barrel and garden in back

*Properties with --- under the column 'downspouts' must have gutters installed for the suitable green infrastructure to be effective.

Our assessment shows us that only 60 percent of the homes on this street are equipped with gutters, which are essential for the use of rain barrels or rain gardens. Of the homes that do have gutters, 67 percent have at least one main downspout that drains directly onto the driveway. Any water that is drained to the driveway has no chance to infiltrate into the ground, and ultimately runs directly to the storm drains on the street, contributing significantly to the problem of CSOs.

With a roof area of 750 square feet, each home would contribute about 230 gallons of roof runoff for a ½" rain event, which is a fairly significant rain event in the Syracuse area. That means for every ½" of rain, the homes on Vincent Street contribute approximately 4,600 gallons of rain water to the combined sewers. That means over the course of one year, the homes on this street alone produce over 374,000 gallons of runoff. That number does not even account for the impervious surface area of driveways, sidewalks and the street itself. If we were to include those surfaces as well, this one street's total contribution to the sewers would be over 15,000 gallons for a ½" event and 1.2 million gallons annually!

If our recommendations were implemented, the rain barrels on Vincent Street would stop 1,430 gallons of water from entering the storm drains in a ½" rain event, and the rain gardens would capture an additional 1,380 gallons. That’s a total of 2,810 gallons abated by simple green infrastructure on one street!

Harriet Street

During one of our trips around sewershed 077 to make property assessments, one house stood out as a perfect example of how a residential rain garden can help reduce runoff. After an assessment of 252 Harriet Ave, we made some calculations and designed a garden that would be able to abate 50 percent of the runoff coming from the house roof and 50 percent of the runoff coming from the garage roof (Figure 9). The house has very little vegetation for interception, but has a large open side lot that would be the perfect location for a rain garden. The yard has about a six percent slope that directs runoff from the downspouts toward the street. Based on the area of roofs being drained toward this side lot (612 sq. ft.), the six percent slope of the yard, and the infiltration rate of the soil type, we recommend a rain garden six inches deep with an area of 153 square feet. Even though a ½” storm event would only produce 190 gallons of runoff from these surfaces, this garden could hold up to 500 gallons in a higher flow event. This particular design would stop 15,000 gallons of water annually from entering the storm sewers. This design is not only functional, it is aesthetically pleasing with a variety of flowering plant species.

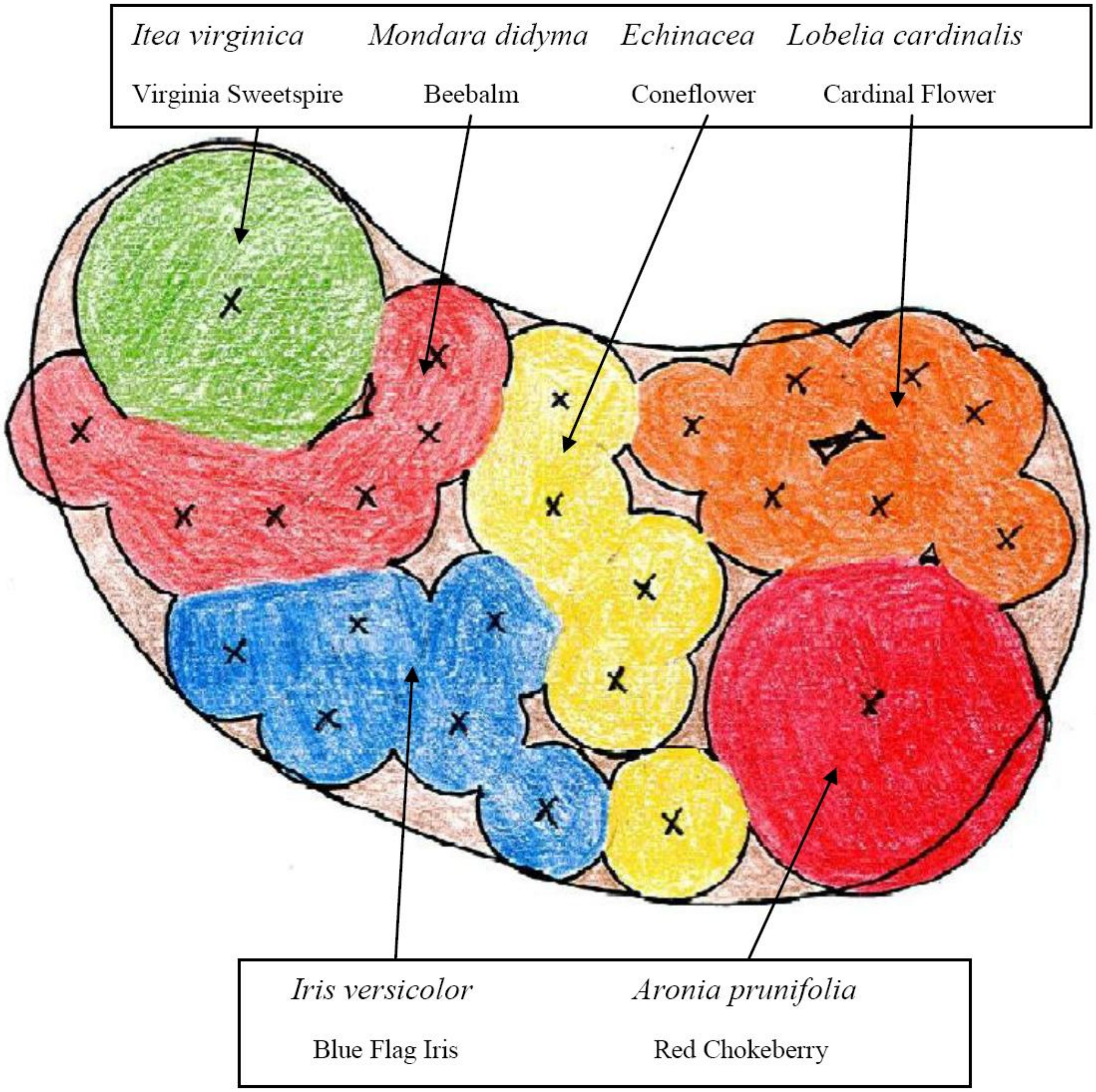

Figure 9. Rain Garden design for 252 Harriet Ave.

Results—Institutions

Percy Hughes School

As part of our biocultural restoration efforts, we considered the education of young people to be extremely important, after all it is these young people who will one day be the policymakers and county executives. In an effort to get the school involved with our plans, we met with Vice Principal Larry Schmiegel, the school's head custodian, a faculty member, and eight student members of the Hughes School Green Team. At the meeting we distributed pamphlets about rain barrels and rain gardens, as well as a list of suitable native plants for rain gardens. We educated the team members on the problem of excessive storm water entering the CSOs, and what can be done by each of us to help. Both the students and faculty members were very excited to get involved and to potentially use the school as a model for the community by adding green infrastructure to the property. They really liked the idea of helping out, and seemed to understand that we are all part of a much larger system and that the key to success is working together as a community to improve the place we live. As ideas flew around the room, one student even said she "would love to be a role model" for the community. The students came up with the idea of writing letters to local policymakers, celebrities, and even government officials to try to get funding to start their new project. The teachers were looking forward to using this opportunity for some hands-on science experience for their students. Overall, the receptivity at Hughes school was inviting, and it was wonderful to see young people so eager to help solve this environmental nightmare.

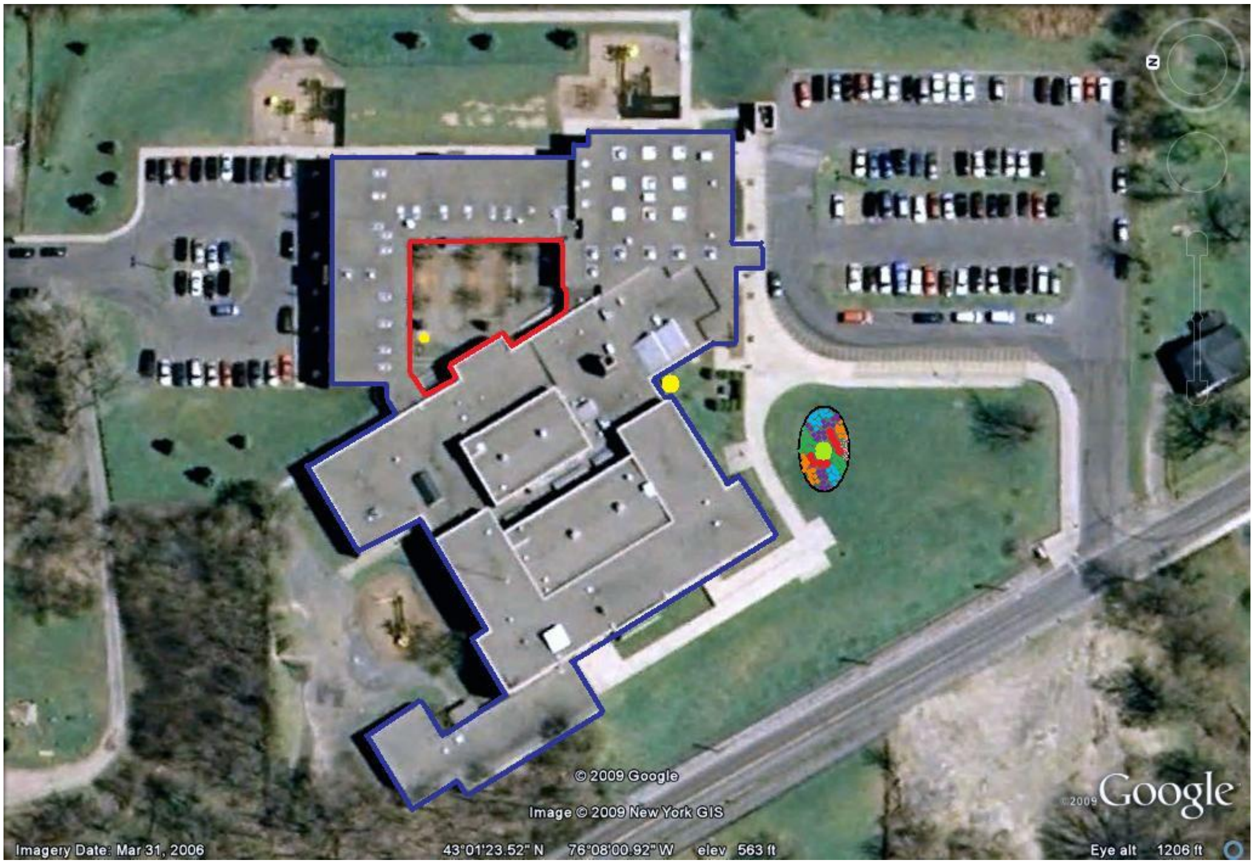

Figure 10. Preliminary Design for Hughes School.

Figure 10 is a satellite image of the Hughes Elementary School property. Outlined in red is the courtyard where school events are held and students thought of planting gardens there to help capture some of the runoff. Outlined in blue is the rooftop of the school. The courtyard and roof surface areas are approximately 7,500 square feet and 62,800 square feet, respectively. In a ½" rain event, the school's impervious surface produces about 21,900 gallons of water. This is an enormous contribution to the problematic CSOs, and steps should be taken to reduce the contribution. The design in Figure 10 includes a 55' by 30' rain garden in the front of the school, adjacent to the parking lot. This size garden will be able to capture just over 8,000 gallons of water during a storm event, and will be able to support a wide range of plant diversity. Downhill of the rain garden, a series of vegetated berms should be installed to capture any additional water that runs down the slope, should the garden fill beyond capacity and spill over. There is also a

5,000 gallon cistern that will be used to collect roof runoff, and can be drained into the garden after the 8,000 gallons from the initial storm surge have had ample time to infiltrate into the substrate.

Parking lots on school property add another 60,000 square feet of impervious surface, the runoff from which could be reduced through pervious pavement strips, rain gardens, swales.

As for the courtyard in the middle of the school, we suggest removing two of the pear trees, and replacing them with a rain garden of native plants. The remainder of the open courtyard should slope toward the garden, so the precipitation that lands in the courtyard will be directed to the garden for infiltration. The garden would be rectangular, 15' wide and 32' long, giving it an area of 450 square feet and able to account for 2,393 gallons of runoff, making it just large enough to capture the rain on the courtyard in a ½" rain event. Directly adjacent to the garden, there should be a drain that leads to a subsurface drywell to help with the infiltration of garden overflow in a higher flow event.

Syracuse University

Syracuse University owns a portion of the property in sewershed 077. We approached Rachel May, Director of the Office of Environment and Society at SU and SUNY ESF, about GI projects on SU lands in Sewershed 077. This area would include some of the more visible properties in the entire sewershed—for example, the Manley Field House complex at the corner of Comstock Avenue and Colvin Street. May responded with much interest, but said her hopes were for a project on North Campus, for example the steep hill below Crouse College, since that is where admissions tours start.

RECOMMENDATIONS

Long term: Increase Percent GI

For the long term, we recommend aiming for an increase in percent stormwater treated by GI. Since GI often depends on plant material that must establish and grow, it can take some years to reach its full potential. In the meantime reliance on relatively benign gray methods (such as underground storage) will be necessary to treat the majority (95 percent) of stormwater generated in the Syracuse area.

To maximize GI services to the community, we recommend thinking in terms of large-scale renaturalizing of urban areas via urban forestry, habitat gardens, wetland and waterway restoration. The watershed benefits of forest cover extend beyond stormwater treatment to include:

- improving regional air quality
- sequestering carbon
- reducing stream channel erosion
- adding beauty, quality of life
- providing habitat for terrestrial and aquatic wildlife
- improving soil and water quality
- reducing summer air and water temperatures (USDA 2005).

These benefits support the goals of the ACJ and of the Onondaga Land Rights Action. Rather than a single tree in the back yard (debatable as restoration), the collective and coalescing effects of increasing plant cover can aid in urban ecosystem recovery. This process could change our whole idea of cities, and blur the distinctions between city and country, humans and nature. In the words of artist Patricia Johansson:

> It would be much more sensible, aesthetically pleasing, and beneficial to let natural processes determine urban form, so neighborhoods would exist within a matrix of reconnected, self-sustaining, and regenerative nature.
> Thus [urban landscapes such as Syracuse] could ameliorate flooding, collect and store drinking water, filter out pollutants, and restore biological richness, while at the same time providing opportunities for recreation and education (Kelley 2006).

Using Biocultural Restoration Tools

There are many ways the county could implement biocultural restoration tools. Neighborhood associations could organize information sessions and neighborhood work days where neighbors go around and help each other install rain barrels and gardens. Trained volunteer groups (e.g. Girl or Boy Scouts, church groups and school groups) could also help with the effort. This would create a sense of mutuality and community and ensure that the projects are completed. As an incentive, neighborhoods could document their progress by generating a Green Map of their GI installations and hold a contest for the "greenest" community.

Organizers could use problem-solving tools such as "social mess" mapping to help clarify and work through multifaceted challenges to the county's GI plan. This would help make the process more transparent and encourage broader participation from the community.

A county employee or other representative could serve as a regional coordinator for volunteer groups to facilitate their work. The coordinator's role would be to assist groups by organizing networking meetings, social opportunities, training and skill-sharing sessions, problem-solving and, if necessary, conflict resolution.

Attention should be paid to transforming restoration processes and goals to be more human-oriented. Planners could encourage creativity through art, grants, contests or school programs (starting with Hughes School!) and provide leadership and learning opportunities to make the experience more engaging and empowering. People's needs and reasons for volunteering should also be taken into consideration when planning volunteer events in order to make the restoration process enjoyable and successful.

Exploring bioregional activism and restoration in other communities—such as the Putah-Cache Bioregion Project in California, the prairie restoration activities of Chicago Wilderness, and the Portland Community Watershed Stewardship Program—may provide inspiration, encouragement and useful examples for Syracuse as it reinvents itself with GI. The Putah-Cache Bioregion Project website has compiled a comprehensive bibliography of bioregionalism literature from many locales and viewpoints.

Transform Transport

Much impervious surface area (for example streets, parking lots) relates to transportation, and much of that potentially relates to a transportation system based on the private automobile. Rapid developments in the field of mobility are usually monofunctional and tend to proliferate, i.e. to generate the need for further transportation requirements (van Bohemen 2002). Although road infrastructure may take up a small fraction of surface (1-5 percent), negative impacts can extend to 20-25 percent of the surface area. This "annoyance" consists of noise, air, soil, and water pollution as well as devastating effects on nature (fragmentation, road mortality, passage for travel of noxious weeds, effects of sound and lighting on breeding birds).

The environmental costs of reliance on private automobiles are indeed staggering. Contributions to acid rain and climate change; indirect effects due to impacts of fossil fuel extraction; not to mention thousands of square miles of forest, meadows, or wetlands replaced by impervious surface cover (pavement) illustrate just a fraction of the price we pay for the convenience of traveling (as Douglas Adams quips) faster from Point A to Point B.

Our transportation has much to do with green infrastructure. Reduced use of cars would reduce need for parking lots and sprawling development in general. What if the business siphoned off to Carousel Mall and the sadly named "Destiny" went downtown? People don't go downtown, often, due to the challenge of parking. Improving public transportation—making it safe, convenient, affordable, easy to use, efficient—could free us from the tyranny of the car and thus indirectly increase opportunities for green space.

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