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A Green Infrastructure framework for vacant and underutilized urban lands *

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ABSTRACT: In just over a decade, green infrastructure planning has evolved from a novel buzzword into a recognized planning practice (Allen, 2012). The United States now has an array of organizations and public agencies involved in implementing green infrastructure, and the approach has inspired extensive research in the United Kingdom and Western Europe (Mell, 2008). Current best practices in green infrastructure planning attempt to link and coordinate planning and implementation across three spatial scales – site, regional, and landscape (McDonald et al., 2005) along the urban/rural continuum, with specific implementation strategies at each scale. Although green infrastructure planning is usually associated with 'growing' communities and often begins at the landscape scale (Benedict and McMahon, 2006), the green infrastructure planning approach also applies to 'shrinking' communities. Nonetheless, more applied research is needed to generate sufficient scale to transform a landscape into an interconnected, functional network of urban ecological systems that provide multiple benefits for people and nature. This paper attempts to synthesize best practices to date with a multi-scale green infrastructure approach to establish an operational framework that results in functional landscapes within patchworks of abandoned, vacant, or underutilized properties. The framework can be broken into the following components:

1. Analyze the landscape and regional context for site scale implementation
2. Engage the community with long-term vision and short-term opportunities
3. Identify the typology of potential green infrastructure activities
4. Craft implementation project selection criteria
5. Optimize the project investment portfolio

This approach needs to be tested in some "living laboratories" that provide strategic opportunities to effectively apply the framework. The Conservation Fund hopes to test this framework for site scale green infrastructure implementation in its ongoing projects over the next few years. If successful, this framework could be consistently applied to ongoing planning efforts by cities and organizations in the US and around the world.

Keywords: Green Infrastructure, functional landscapes, urban greening, LSP method, optimization

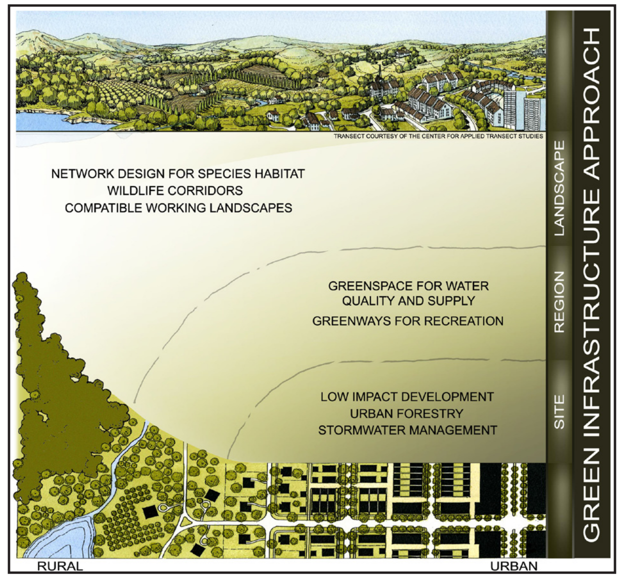
INTRODUCTION

In just over a decade, green infrastructure planning has evolved from a novel buzzword into a recognized planning practice (Allen, 2012). In the United States, the term green infrastructure first appeared in the mainstream as one of five strategic areas of sustainable community development by President Bill Clinton's Council on Sustainable Development (1999). The US now has an array of organizations and public agencies involved in implementing green infrastructure, and the approach has inspired extensive research in the United Kingdom and Western Europe (Mell, 2008).

Allen (2012) documents the evolution of the definition of green infrastructure in the US, with all commonly accepted definitions having the objective of establishing an interconnected network of natural areas that provides environmental, social, and economic benefits to human populations. The concept has recently evolved to include techniques and technologies that use natural systems – or engineered systems that mimic natural processes – to enhance the built and natural environment, particularly within the practice of stormwater management (Center for Neighborhood Technology & American Rivers, 2010). The benefits accrued by green infrastructure, such as human health, wildlife habitat protection and enhancement, water quality and supply, air quality, and reductions in greenhouse gas emissions, also can help achieve the regulatory, program, and plan implementation goals of public agencies and cities.

Current best practices in green infrastructure planning attempt to link and coordinate planning and implementation across three spatial scales – site, regional, and landscape (McDonald et al., 2005) along the urban/rural continuum, with specific implementation strategies at each scale (See Figure 1). Allen (2012) presents a general framework for green infrastructure that can be advanced at each of these scales. Green infrastructure strategies range from protecting and restoring large blocks of intact natural systems to applying "green engineering" techniques to increase stormwater infiltration in urban areas for runoff reduction and flood mitigation (USEPA, 2013). Each of these scales addressed the natural and urban environments, since "[w]e must think about cities and the human-built environment as not being separate from, but rather interconnected with, the natural environment, and what that implies for people and nature in urban areas (MGA, 2013)."

Figure 1 – The Scales of Green Infrastructure Planning



Although green infrastructure planning is usually associated with 'growing' communities and often begins at the landscape scale (Benedict and McMahon, 2006), the green infrastructure planning approach also applies to 'shrinking' communities. Schilling and Logan (2008) outline a model for 'right sizing' shrinking cities through green infrastructure plans and programs, land banks, and community consensus through collaborative neighborhood planning. Nonetheless, more applied research is needed to generate sufficient scale to transform a landscape into an interconnected, functional network of urban ecological systems that provide multiple benefits for people and nature. Functional landscapes that provide wildlife habitat, stormwater management, groundwater infiltration, local food security, and other benefits can be strategically identified and restored, and cost effectively implemented, to create more healthy cities, even amidst a shrinking human footprint.

This paper attempts to synthesize the best practices to date from successful shrinking cities initiatives with the multi-scale green infrastructure approach in an effort to establish an operational framework that aims to create functional landscapes within patchworks of abandoned, vacant, or underutilized properties. The goal is for this approach to be consistently applied to ongoing planning efforts by cities and organizations in the US and around the world.

THE RELATIONSHIP BETWEEN GREEN INFRASTRUCTURE, FUNCTIONAL LANDSCAPES, AND SHRINKING CITIES

Initial best practice examples of the green infrastructure planning approach focused on the best natural and recreational areas to protect amidst a projected growth in population and expansion of the urban footprint (Weber et al., 2006; Florida Department of Environmental Protection and Florida Greenways Council, 1998). A recently completed green infrastructure and ecosystem services analysis by the Houston-Galveston Area Council and The Conservation Fund in the Greater Houston region attempts to encourage development in strategic locations to maintain and enhance functional landscapes amidst a projected population increase of 3.5 million people over the next 30 years (The Conservation Fund, 2013; H-GAC, 2010).

The concept of functional landscapes can be defined as "lands and waters with the properties and elements required to support desirable populations of fish and wildlife, while also providing human society with desired goods and services, including food, fiber, water, energy, and living space (USFWS, 2013)." While this definition is currently used by USFWS at the landscape scale to address future habitat conservation scenarios in the context of climate change, habitat fragmentation, energy development, and human population growth, this concept also can be downscaled to orient the re-use of underutilized properties towards productive uses with environmental, social, and economic benefits to urban communities.

Dewar and Thomas (2012) profile various approaches to the shrinking cities phenomenon across the US, with a subset of these approaches involving landscape design and community gardening. Interestingly, the editors observe that "no one has yet produced an approach in any city that officials elsewhere find compelling enough to adopt as well." Henderson (2013), in a book review of Dewar and Thomas, also astutely highlights that Dewar's conversations with leading practitioners in the field, as well as her synthesis of the lessons learned from case examples, offer no solution to shrinking cities without more "reflective practice" and a different paradigm that can create "a better city with little new development," or as Hollander et al. (2009) calls it "a more careful and place-based approach towards more livable cities."

Three keys to expanding this paradigm are: 1) to emphasize how the shrinking cities concept is really an element of an exercise in 'right-sizing' (as discussed in Ryan, 2012; Schilling and Logan, 2008) – re-adjusting a city's built environment to match its current and projected population and development trends, 2) to highlight that productive uses can be income generating, can reduce the cost of regulatory compliance, and can reduce the need for gray infrastructure capital investments, and 3) to apply this concept much more broadly than what may be envisioned currently by most in this emerging field. According to the US 2010 Census, almost three dozen cities that had populations over 100,000 in 1950 have lost at least 20 percent of their residents (Krohe, 2011), yet cities that are growing still have neighborhoods that could take advantage of right-sizing tools and strategies.

GREEN INFRASTRUCTURE APPROACHES ON VACANT AND UNDERUTILIZED LANDS

The framework has the following components:

1. Analyze the landscape and regional context for site scale implementation
2. Engage the community with long-term vision and short-term opportunities
3. Identify the typology of potential green infrastructure activities
4. Craft implementation project selection criteria
5. Optimize the project investment portfolio

1. Landscape and Regional Context

As the three spatial scales of green infrastructure planning are inextricably linked, a best practice is for a region's large, unfragmented ecosystems to have already been identified on a landscape scale to help identify, protect, and enhance wildlife species habitat, important migration corridors, and functional working landscapes (i.e. farms, forests, ranches). These landscape scale efforts have been completed for many metropolitan areas in the US and also have been completed on a state-wide or multi-state basis (Chicago Metropolitan Agency for Planning, 2013; The Conservation Fund, 2011; State of Maryland, 2013; University of Florida GeoPlan Center, 2001). While not a prerequisite for site-scale analysis, the landscape scale perspective provides valuable insight into the potential demand for income producing uses of underutilized lands, particularly related to local food and urban wildlife habitat, as well as the regional, and even international, economic development context relative to megaregions (Regional Plan Association, 2008).

Although the functional analysis of landscape and regional scales overlap somewhat, the intermediate scale between landscape and site serves as a bridge between broad landscape-scale networks that transcend political boundaries and site-scale activities that are more targeted on an individual parcel within a city. This scale is usually distinguished by having a metropolitan planning organization or similar regional policy making entity using the green infrastructure network to support land-use, transportation, and air quality planning as well as regional recreational networks and watershed-based water quality and supply management (Allen, 2012). A best practice example at this scale in the US is the Regional Conservation Strategy for the greater Portland-Vancouver metropolitan region which focuses on urban and rural landscapes and is paired with a regional biodiversity guide, mapping, and modeling (The Intertwine, 2013).

After understanding the landscape and regional context for site scale activities, strategies can be developed to educate the community on potential opportunities and assessment of potential typologies for green infrastructure projects can begin. Haase (2008) and Hollander (2011) highlight numerous opportunities to expand urban green infrastructure in shrinking cities. A study by Jaffe (2010) suggests that although site-scale strategies can serve landscape-scale functions (such as providing habitat, recharging aquifers, and minimizing erosion), these projects often can stand on their own merits in terms of site-scale green infrastructure benefits. The Regional Plan Association (2012) recently identified successful ways by which planners and policy makers are integrating green infrastructure practices and technologies into land use and site planning decisions. Many potential site scale strategies fall under a large umbrella of low-impact development and urban-scale watershed protection (Center for Watershed Protection, 2013; Low Impact Development Center, 2011). Schwab (2009) presents technical advice for adopting urban forestry as a strategy to reduce gray infrastructure costs, including the measurement of urban forest canopy and the setting of canopy goals.

2. Engage the Community

Schilling and Logan (2008) lay out a conceptual strategy for right sizing with green infrastructure that emphasizes addressing “immediate interests of residents with long-term vision of community viability.” Extensive public involvement processes in Youngstown, Ohio (2005), Cleveland (2008) and Detroit (2012) chronicle the importance of garnering support from community leaders, volunteers, and the public to become actively involved in creating a plan that addresses the declining population of a city. Community involvement has also been important in recent green infrastructure projects (Metropolitan Government of Nashville and Davidson County & Land Trust for Tennessee, 2011; The Conservation Fund, 2011; Allen et al., 2010).

These examples suggest that the desired outcomes of the public involvement process should be to: 1) Identify opportunities to stabilize neighborhoods and develop holding strategies to allow time to assess suitability for development and green infrastructure of vacant and underutilized properties, 2) Document community values through an asset mapping exercise, and 3) Obtain an initial assessment of the feasibility, opportunity, and suitability of available green infrastructure strategies at a parcel level.

3. Identify Green Infrastructure Typologies

Landscape and regional scale green infrastructure mapping combines geographic information systems (GIS) modeling techniques based on landscape ecology and conservation biology principles with the Ian McHarg approach (1967) of map overlays and suitability analysis that assumes the intrinsic landscape attributes of a place should be the basis for land-use planning. Fortunately, these concepts can be downscaled to the site level and applied to this context where restoration and re-use are the predominant strategies.

The Northeast Ohio Ecological Consortium (NEO ECO) has developed a Vacant Land Rapid Assessment Procedure (VL-RAP) that provides an efficient way to screen and evaluate sites using basic ecological and ecosystem principles to determine their potential suitability as wildlife habitat, stormwater management, parks, and gardens (Rouse and Bunster-Ossa, 2013; Cleveland Urban Design Collaborative, 2008), with similar efforts undertaken by The Conservation Fund and the Houston Parks Board to rapidly assess potential park opportunities that implemented the city's Parks Master Plan (The Conservation Fund & Houston Parks Board, 2005).

LaCroix (2011), Krohe (2011), Morley (2010), and Bonfiglio (2009) identify an array of green uses for surplus land, including urban agriculture, community green spaces, and alternative energy, while Cleveland (2008) established a useful flow chart that integrates holding and preservation strategies in a rule-based framework. Synthesis of these efforts in conjunction with current and recent Conservation Fund green infrastructure projects with site scale implementation helps generate a set of green infrastructure project typologies that can be organized into three broad categories: 1) Income Generating, 2) Compliance/ Regulatory, and 3) Community Benefit (Table 1).

Each typology can be evaluated for its relative suitability for re-use of a vacant, abandoned, or underutilized property, based on an assessment of public preference, feasibility, opportunity, and the physical resource characteristics of each parcel. While these are described in detail in the following section, an example is that any gardening or agricultural activity on the property will be more suitable if it has access to a public water system. This, along with other considerations, will help differentiate the relative suitability of parcels for green infrastructure investments.

4. Implementation Project Selection Criteria

Once public preferences and green infrastructure typologies have been developed, a transparent, science-based process should be developed to design project selection criteria and quantitatively assess parcels on a consistent evaluation scale. While there are many approaches to designing criteria and assigning weights to different decision making factors, such as the Analytic Hierarchy Process (Messer & Allen, 2010; Saaty, 1990), an approach known as the Logic Scoring of Preference (LSP) method is being increasingly used for resource decision making processes that demand high levels of public transparency (Allen et al., 2011; Dujmović, 2007).

Table 1 – Green Infrastructure Typologies

INCOME GENERATING	
Type	**Examples**
Urban Forest	Carbon bank, harvesting, straw raking
Commercial Harvesting	Native tree / plant nursery
Urban Agriculture	Agricultural entrepreneurs, local food
Food Production in Re-used Buildings	Greenhouse, aquaponics
Alternative Energy	Solar, wind, geothermal, methane to energy
COMPLIANCE / REGULATORY	
Type	**Examples**
Stream/Riparian Restoration	Stream daylighting, culvert removal
Stormwater Park	Constructed wetland, rain garden
Phytoremediation *(i.e. plantings to mitigate contamination without excavation)*	Sunflower planting for toxics absorption
Impervious Surface Reduction	Parking lot / concrete removal
COMMUNITY BENEFIT	
Type	**Examples**
Local Recreation Facilities	Pocket park, playground, ball courts
Recreational Trail Linkages	Pave bike path, unpaved trail
Non-production Garden	Native plant / habitat garden (e.g. grassland/prairie/savannah)
Community Garden	Local food, multiple resident plots for household consumption

The LSP method is a scientifically rigorous technique originally developed for computer science applications to design project selection criteria and weightings that reflect fundamental properties of human reasoning and ensure that the benefits calculated accurately reflect the desired intent of decision makers (Dujmović, 2007). In the LSP method, project criteria are developed through a collaborative process with stakeholders and subject matter experts to ensure all attributes that can be measured are included for evaluation and can represent an overall level of satisfaction (Dujmović and Allen, 2011).

The LSP method organizes criteria into "attribute trees" in order to evaluate quantitatively the benefits of potential opportunities on a consistent scale so that projects can be appropriately compared. Based on a synthesis of Cleveland (2008) and Detroit (2012), as well as previous Conservation Fund LSP implementation projects, the attribute tree for identifying suitable re-use of vacant, abandoned, and underutilized properties for green infrastructure can be organized into four 'branches': 1) Community Support, 2) Feasibility, 3) Opportunity, and 4) Resource Value (Table 2).

These criteria would be further evaluated and weighted during the public input process before parcel scores were calculated.

OPTIMIZING THE PROJECT INVESTMENT PORTFOLIO

When demand for green infrastructure investments outstrips the resources available to implement projects, optimization may be used to help select the best available opportunities within the financial and human capital constraints of a shrinking city. Optimization is a branch of economics and operations research studies that in recent years has shown conservation professionals how to get more green infrastructure investments completed within constrained budgets or achieve the same level of benefits from conservation projects with a smaller budget (Duke et al, 2013; Allen et al, 2011; Messer and Allen, 2010; Messer, 2006).

Rather than selecting the highest ranked projects without regard to the implementation cost, an optimization model uses a mathematical programming technique and can integrate the quantitative data from the LSP method and

Table 2 – LSP Attribute Tree for Identifying Suitable Green Infrastructure Investment Opportunities on Vacant and Underutilized Lands

1 Green Infrastructure for Vacant and Underutilized Lands

11 Community Support
- **111 Local Preference for Reuse**
  - **1111 Support for Green Infrastructure**
  - **1112 Support for Redevelopment/Infill**
  - **1113 Support for Abandonment**
- **112 Local Preference for Specific Typology**
  - **1121 Income Generating**
  - **1122 Compliance/Regulatory**
  - **1123 Community Benefit**
- **113 Local Interest in Installation/Maintenance of Typology**
- **114 Existing Plan Focus Area for Reuse**

12 Feasibility
- **121 Competing Land Uses**
  - **1211 Redevelopment Suitability**
  - **1212 Neighborhood Stabilization Potential**
- **122 Complexity**
  - **1221 Ownership Status**
  - **1222 Building/Demolition Status**
  - **1223 Remediation Status**

13 Opportunity
- **131 Size/Configuration**
  - **1311 Lot/Block Size**
  - **1312 Configuration**
  - **1313 Expansion Potential**
- **132 Strategic Location**
  - **1321 Proximity to Existing Schools**
  - **1322 Proximity to Public Service Facilities**
  - **1323 Proximity to Existing Parks/Greenspace**
- **133 Service from Water/Utility Infrastructure**

14 Resource Value
- **141 Site Characteristics**
  - **1411 Existing Vegetation/Habitat**
  - **1412 Soil Characteristics: Hydric, Drainage, Suitability**
- **142 Functional Connectivity**
  - **1421 Floodplain**
  - **1422 Groundwater Infiltration**
  - **1423 Stream/Wetland System**
  - **1424 Recreation Corridor**
  - **1425 Wildlife Corridor**

other data sources in order to identify the set of projects that maximizes the aggregate public benefits given a specified budget (Kaiser and Messer, 2011; Allen et al., 2011). This approach is especially valuable in a shrinking cities context when budgets are acutely constrained and an analysis of the property's 'revenue generating' potential is key to comprehensively assessing a parcel's value. Revenue generation, in this context, can mean future increases in property taxes, reductions in combined sewer overflow (CSO) compliance costs, reduction in gray infrastructure maintenance costs, and other equivalent measures. Thus, the application of optimization in a green infrastructure context in a shrinking city is likely to pay off considerably from a return-on-investment perspective.

CONCLUSION

This green infrastructure approach on vacant and underutilized urban lands needs to be tested in some "living laboratories" that provide strategic opportunities to effectively apply the framework. The Conservation Fund hopes to test this framework for site scale green infrastructure implementation in its ongoing projects over the next few years. If successful, this framework could be consistently applied to ongoing planning efforts by cities and organizations in the US and around the world.

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