Sustainable Healthy Cities

A National Science Foundation-supported Sustainability Research Network (SRN)

JOURNAL BRIEF: Hotspot Analysis and Strategic Siting of Green Infrastructure to Maximize Ecosystem Service Provision

Sustainable Healthy Cities Journal Brief - 2018, No. 3 - Green Infrastructure Siting

This brief is adapted from the following peer-reviewed journal article: Meerow, S. & J.P. Newell. (2017). "Spatial planning for multifunctional green infrastructure: Growing resilience in Detroit." *Landscape and Urban Planning*, 159 (2017) 62–75.

Study Intent and Research Question

Ecosystem services are the social and ecological benefits that are provided to humans by the natural environment. Where should cities strategically locate green infrastructure (GI) to address the needs of areas with specific ecosystem service provision deficits? Where should GI be located so that it addresses multiple ecosystem service provision deficits at once? City-wide spatial modeling of ecosystem service needs using the GIS-based 'Green Infrastructure Spatial Planning' (GISP) tool can help identify hot-spot areas ripe for investment based on different service provision goals, including the goal of providing multiple ecosystem services at once.

Key Background Information

GI is commonly associated with the provision of six specific ecosystem services:

1) Storm-water management (Jaffe et al., 2010)
2) Improved air quality (Pugh et al., 2012)
3) Urban heat island mitigation (Tzoulas et al., 2007)
4) Reduced social vulnerability (Cutter & Finch, 2008)
5) Access to green space
6) Landscape connectivity (Mitchell et al., 2013)

The spatial data needed to run a GISP model similar to the one deployed in Detroit are identified in the table below. These are commonly available GIS layers for most cities.

Table 1- GISP Model Spatial Data Inputs

Ecosystem Service	Spatial Attribute
Stormwater Management	Average runoff coefficients based on Rational Method and CSO outfall location data
Reduced Social Vulnerability	Social Vulnerability Index
Access to Green Space	Estimate of tract population without access to parks
Urban Heat Island Mitigation	Average land surface temperature
Improved Air Quality	Particulate matter (PM2.5) emissions
Landscaoe Connectivity	Connectedness of wildlife habitat (forest cover)

Key Findings

Due to varying ecosystem service needs across a city, the impact of GI installations are not felt equally in all areas. For example, some areas of a city are more in need of GI's air pollution mitigation benefits than other areas (i.e. areas with poor air quality). Similarly, other areas are more in need of GI's stormwater abatement benefits than others (i.e. areas that experience regular flooding).

Within a given city, there will be GI siting synergies—where the optimal siting to maximize the impact of one eco-system service simultaneously supports enhanced impact of other ecosystem services. Within that same city, there will also be GI siting tradeoffs—where the optimal siting to maximize the impact of a particular ecosystem service detracts from the ability to maximize the impact of other ecosystem services.

SYNERGIES

In Detroit, GI siting decisions to maximize stormwater management, reduce urban heat island effects, and improve air quality are all positively related, meaning that siting decisions to advance one of these service priorities, in effect, advances all of them.

TRADEOFFS

In Detroit, GI siting to maximize landscape connectivity is negatively related with siting to address stormwater abatement, to reduce urban heat island effect, and to improve air quality. This means that optimal locations for GI to increase landscape connectivity will not be optimal for maximizing

stormwater abatement, urban head island regulation, or improved air quality benefits.

HOTSPOT ALIGNMENT
Expert stakeholders in Detroit identified storm-water management, reducing social vulnerability, increasing access to green space, and improving air quality as ecosystem service priorities. Current siting of GI in Detroit aligns with 'hotspot' areas for increasing access to green space, but does not align with 'hotspot' areas for storm-water management needs, reducing social vulnerability, or improving air quality.

Policy and Practice Implications

GISP models can identify hotspots ripe for investment based on city-specific ecosystem service provision priorities. This type of analysis can be run for any city with the requisite spatial data layers (see table 1). The referenced paper can provide greater detail on methodology for city practitioner's interested in performing this type of analysis.

Hotspot analysis can be customized to identify siting locations that address different priorities. For example, siting can be optimized to maximize the impact of an individual ecosystem service by siting where that service is most needed. Alternatively, siting can be optimized to prioritize multi-functionality by locating investments only in areas where multiple service provision priorities overlap.

GISP can help decision makers evaluate whether current and planned green infrastructure installations align with articulated service provision goals and policy priorities. In the event that investments are not aligned with these goals and priorities, hotspot analysis can help to guide investments so that they better align.

Green Infrastructure

Co-benefits & Tradeoffs

Policy & Governance

Further Reading and References

-Cutter, S. L., & Finch, C. (2008). Temporal and spatial changes in social vulnerability to natural hazards. Proceedings of the National Academy of Sciences of the United States of America, 105(7), 2301–2306. (Open Access)
-Jaffe, M., Zellner, M., Minor, E., Gonzalez-Meler, M., Cotner, L., Bucci, M.D., Miller, B., The illinois green infrastructure study: A report to the Illinois Environmental Protection Agency on the criteria in section 15 of Public Act 96-0026, The Illinois Green Infrastructure for Clean Water Act of 2009, 2010, Chicago, IL. (Open Access)
-Mitchell, M. G. E., Bennett, E. M., & Gonzalez, A. (2013). Linking landscape connectivity and ecosystem service provision: Current knowledge and research gaps. Ecosystems, 16(5), 894–908.
-Pugh, T. A. M., Mackenzie, A. R., Whyatt, J. D., & Hewitt, C. N. (2012). Effectiveness of green infrastructure for improvement of air quality in urban street canyons. Environmental Science & Technology, 46(14), 7692–7699.
-Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kazmierczak, ´ A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. Landscape and Urban Planning, 81(3), 167–178.

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The Sustainable Healthy Cities Network is a U.S. National Science Foundation supported sustainability research network focused on the scientific advancement of integrated urban infrastructure solutions for environmentally sustainable, healthy, and livable cities. We are a network of scientists, industry leaders, and policy partners, committed to building better cities through innovations in infrastructure design, technology and policy. Our network connects across nine research universities, major metropolitan cities in the U.S. and India, as well as infrastructure firms and policy groups to bridge research and education with concrete action in cities.

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