Study Intent and Research Question

Which green infrastructure (GI) types most directly link to which ecosystem services? This study surveys expert opinion across disciplines to conceptually map connections among 14 GI types and 22 ecosystem services. There is a lack of data to support holistic ecosystem services decision-making as part of larger urban infrastructure and planning efforts. In addition to empirical validation and field testing, understanding expert opinion can help chart well-established connections between various GI types and ecosystem services to support planning and decision making.

GI types considered: wetlands, community gardens, intensive green roofs, street trees, bioswales & green streets, rain gardens, vine canopies, extensive green roofs, green facades, retention ponds, rain cisterns, permeable pavement, vacant land.

Ecosystem services considered: cultural (recreation/ tourism, spiritual/cultural/aesthetic, science & education, social interaction); regulating, supporting and maintenance (water quantity mitigation, climate regulation, habitat supporting, pollination, air purification, water quality improvement, erosion control, nutrient cycling, water conservation, soil formation, noise reduction, pest control); provisioning (ornamental resources, food production, water supply, raw materials, medicinal resources).

Key Background Information

GI is used to describe networks of green spaces, including natural areas (e.g waterways, woodlands) and built areas (e.g. parks, community gardens), as well as engineered structures (e.g. bioswales, permeable paving, rainwater cisterns) (US EPA 2014).

GI is associated with stormwater management benefits, mimicking natural hydrologic processes and/or reducing urban runoff.

Municipalities developing GI programs for stormwater management to meet water quality standards are required to quantify stormwater benefits.

GI is thought to generate ecosystem services beyond stormwater management, such as air pollution reduction, carbon sequestration, and aesthetic benefits (Millennium Ecosystem Assessment 2005).

Performance metrics for non-stormwater co-benefits are not fully defined and have not been robustly assessed.

Even when experts reach consensus, expert opinion is not a guarantee of empirical validity, but provides a way to move forward in complex situations and offers a base for validation.

Key Findings

The most positive ecosystem services linked to GI are water quantity mitigation; science and education; habitat supporting; and spiritual, cultural, and aesthetic.

Pest Control is found to be the only consistent disservice provided by GI.

Expert judgement of Cultural Services shows them to be most universally provided by GI, followed by Regulating, Supporting, and Maintenance Services, and finally Provisioning Services.

Science and education topped cultural services across GI types. Social Interaction and spiritual, cultural, and aesthetic services are found to be highly positively linked with parks and community gardens and only negatively linked to vacant land.

Expert judgement of the three most beneficial GI types with respect to ecosystem services are parks, wetlands, and community gardens, all within the vegetated land category.

Two of the lowest ranked GI types are cisterns/rain barrels and permeable paving, constituting non-vegetated

stormwater GI.

Vacant land is the lowest ranked GI type.

The pool of participants across all disciplines are most confident about cultural ecosystem services, followed by regulating, supporting and maintenance, and provisioning.

Policy and Practice Implications

Despite being strongly linked to multiple GI types by expert opinion, cultural services of GI are the least empirically and spatially investigated on a landscape scale. Cultural services are often more obvious and easier to see for the average urban resident, unlike other valuable ecosystem services, which are often invisible without advanced knowledge of ecological processes (Andersson et al., 2015).

Because cultural services are more often visible and can affect the daily experiences of the average urban resident, developing a better understanding of their linkages to the less visible ecological processes and services is necessary for making a case for making investments in both kinds of services (Nassauer, 2011).

The visibility or widespread understanding of ecosystem services provided by GI can help build support for stewardship programs for urban GI, whose success might rely more on public perception of the cultural services provided by GI than other ES categories.

Holistic application of ecosystem services to GI planning might be better served by considering city-scale infrastructural goals and local-scale cultural impacts separately.

Green Infrastructure

Further Reading and References

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About the Sustainable Healthy Cities Network

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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