



Towards the intentional, multifunctional design of green infrastructure

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Nature-Based Solutions (NbS), which are mitigation measures seeking to protect, manage, and restore ecosystems, have been lauded as a solution to multiple environmental challenges in urban areas, including adaptation to climate change and protection of biodiversity. NbS are particularly compelling due to their perceived multifunctionality, or the ability to *simultaneously* perform multiple ecosystem functions or deliver multiple ecosystem services. However, after several decades discussing the ideas surrounding this broad vision, the implementation of multifunctional NbS in urban areas remains elusive. As several authors have pointed out, this can be due to poor coordination between planning and implementation efforts of NbS elements at the site-level, referred to here as “green infrastructure” (GI). GI are typically designed for one, maybe two purposes, such as water absorption and/or shade, while other ecosystem services and benefits of GI are a passive consideration, assumed to occur based on principles of ecology. With this approach, the lessons learned, management and best practices of these elements are siloed, and synergies within green infrastructure implementation efforts are often overlooked, limiting comprehensive design and consideration of multi-functionality.

In this literature analysis, we offer a new perspective for the holistic design of multifunctional green infrastructure. First, we identify 15 types of GI elements that encompass a larger system. Second, we establish the “design objective” as a way to intentionally consider various ecosystem functions or benefits before GI implementation. Based on a literature review, we identify 13 design objectives, such as stormwater management, heat mitigation, biodiversity, human health & well-being, and social justice. By cross analyzing the GI elements and design objectives using literature queries, we find that most objectives are indeed siloed among particular elements. For instance, literature on stormwater management-focused elements, such as vegetated and non-vegetated infiltration systems (e.g., rain gardens), is dominated by stormwater management papers. Biodiversity is repeatedly considered in papers related to GI elements that are seldom associated to stormwater management (e.g., trees, parks). Design objectives related to social justice are largely lacking from the GI literature, with the exception of parks, trees, and urban gardens. These

findings highlight that efforts for multifunctional GI planning will need to be coordinated across design objectives and elements. Yet, with a vast number of objectives to consider, evaluating all options before implementation may eventually impede the decision-making process and lead to a paradox of choice. A solution could be to follow principles of flexible and adaptable design, allowing for changes in the system along the way to account for new information. Ultimately, inter and transdisciplinary collaboration, research, and coordination are needed to address this multifaceted and critical issue.