



Guest Editorial, part of a Special Feature on [Holistic Solutions Based on Nature: Unlocking the Potential of Green and Blue Infrastructure](#)

Based on nature, enabled by social-ecological-technological context: deriving benefit from urban green and blue infrastructure

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Although green and blue infrastructure (GBI) is recognized throughout the world for its multifunctionality and its large potential to effectively target and engage with existing and novel urban challenges, such as climate change or public health, the full understanding of how it fits into the social, ecological, and technological totality of the urban system lags behind. A widely held assumption is that GBI's inherent multifunctionality means that it may deliver societal benefits while also supporting biodiversity conservation and climate change mitigation and adaptation objectives (e.g., Gómez-Baggethun et al. 2013, Haase et al. 2014, Pauleit et al. 2019, Egerer et al. 2021). Less clear, however, is in what settings and under what conditions urban residents differing in age, socioeconomic status, ethnicity, or interests may perceive and benefit from urban GBI. Interlinkages between GBI and the built infrastructure, institutions, and residents of the city are positioned as a strategic, if still contested, nexus in urban planning (e.g., Pauleit et al. 2019) and key to wider urban multi-actor governance (e.g., Buijs et al. 2016, Frantzeskaki et al. 2019). This special feature, “Holistic Solutions Based on Nature: Unlocking the Potential of Green and Blue Infrastructure,” builds primarily on the ENABLE project (<https://www.biodiversa.org/1014>) and focuses on the need for context-sensitive approaches where urban quality of life is understood as co-produced by multiple interlinked factors.

The special feature continues a long tradition of trying to understand the generation and use of ecosystem services in cities. Already in the early 20th century, Park, Burgess, and colleagues at the Chicago School of Sociology had applied ecological theory of patterns and processes (Burgess 1925; see McDonnell 2011) to describe the structure and function of cities as “social ecology” (Park and Burgess 1925, Hawley 1944). These ideas took flight eight decades later, when the Millennium Ecosystem Assessment (2003) turned ecosystem services into a widely used framework for discussing the role functioning ecosystems and natural capital have for human well-being. Drawing on valuation aspects, in particular, the TEEB (The Economics of Ecosystems and Biodiversity) initiative published its synthesis report in 2010 (TEEB 2010), followed by a manual for cities (TEEB 2011) and a report specifically targeting local and regional policy makers (TEEB 2012). Globally, the integration of disciplines and perspectives inherent in the use of ecosystem services took a big step forward in 2010 when the Convention on Biological Diversity (CBD), at the 10th meeting of the conference of the parties (COP)

in Nagoya, Japan, adopted a plan of action co-developed by and for local governments. At the global level, the Cities and Biodiversity Outlook (CBO) project was initiated in 2011 to support an overall assessment and offer further guidance (Elmqvist et al. 2013), recently followed by a global environmental outlook for cities (United Nations Environment Programme 2021, United Nations 2022). In parallel, emerging green infrastructure strategies fostered nature to be considered an integral part of planning and multi-actor decision making across sectors, scales, and different landscapes (European Commission 2014). In this vein, the concept “nature-based solutions,” pioneered by the International Union for Conservation of Nature (IUCN 2012), has challenged the conventional engineering and technological approach to build resilience to urban hazards such as flooding and heat waves (European Commission 2014) by ecosystem-based “actions” (United Nations 2022). The approach has developed rapidly as local governments are increasingly grappling with the challenges of climate change-induced extreme weather events and adaptation in densely built environments.

The role of people in the production of ecosystem services and their potential well-being has since then become increasingly nuanced (Ernstson 2013, Andersson et al. 2015, Palomo et al. 2016) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has further developed a global framework to think about relationships between humans and nature, anchored on the notion of nature's contributions to people (Díaz et al. 2015). Rather than societally important ecosystem functions, ecosystem services are instead positioned as emergent outcomes of social-ecological interactions (e.g., Keeler et al. 2019, Lin et al. 2021, Tzoulas et al. 2021).

The global interest in urban resilience and quality of life, urban GBI, nature-based solutions, environmental and social justice, and many more fields of inquiry has resulted in an increasingly rich toolbox of methods, evaluation frameworks, indicators, and critical perspectives (e.g., McPhearson et al. 2016, Biernacka and Kronenberg 2018, Wolff and Haase 2019, Langemeyer and Connolly 2020). Moving forward, the articles in this special feature recognize the unique character of place, location, and situation while still striving to elicit universally relevant and transferable knowledge. Central to all of the contributions is a recognition of the importance of context, something that is often shunned as noise in science and research (e.g., Funtowicz and

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Ravetz 1993, Gibbons 2000). Taking a social-ecological-technological systems approach to GBI and the benefits urban residents receive from it, we showcase three critical factors (filters) that influence the realization and distribution of benefits from GBI: infrastructures (composition and configuration of the urban physical landscape, integration of GBI and grey-built infrastructure); institutions (land tenure, rights, rules, and norms); and user perceptions and capacities (such as people's diverse individual preferences and shared or conflicting values; Andersson et al. 2019, 2021a).

In the special feature, we explore new ways of combining concepts, methods, tools, and approaches to advance our understanding of urban system complexity through a set of studies examining local contexts and situatedness, systemic interactions, barriers, and enabling factors behind delivery and distribution of ecosystem service benefits, and insights from inter- and transdisciplinary learning processes. Methodologically, the articles in the special feature attest that there are no universal approaches, templates, or standard methods that will work across all cases, especially not given the diverse nature of urban contexts, GBI benefits, and their interactions with the three filters. Instead, the authors in the special feature have sought to identify which questions to ask and how to provide epistemologically agile methodological approaches and tools for seeking to answer them. The three filters framework, explicit or implicit in the attention given to context, and the unifying systems approach used in many of the papers provide a generic approach to positioning and aligning different methods and data as well as different theoretical components and themes. It can especially help us address new research questions or re-evaluate existing case studies and prevailing "truths." We see several possibilities to use the framework to support cross-case comparability without losing case-sensitive depth and nuance, grounded in thematic interlinkages, methods integration, and reflexivity and theorizing back (i.e., constantly re-questioning and re-examining the phenomena under study, the theory behind them, and their connections to other issues).

Greener for all?

Planners and scholars are increasingly asked to account for the accessibility of GBI itself and the opportunities and constraints diverse groups of beneficiaries face when trying to realize different GBI benefits. At the core, this means that variation in terms of GBI availability does not translate to a matching distribution of benefits, which are constrained or enabled by additional factors beyond GBI distribution. Therefore, contextualized, systemic, multi-sector, and multi-actor strategies for GBI planning are needed to better account for other-than-physical constraints, user perspectives, and diversity among users. Collective as well as conflicting perceptions of place, people's role in nature, what constitutes a good life, or the scale at which the city is expected to provide for different needs are changing, not least through social and technological innovation and transformation (McPhearson et al. 2021). These changes affect, differentially across groups and individuals, the ability to make sense of the urban landscape and access its different benefits, which has implications not least for distributional environmental justice (e.g., Low 2013, Biernacka and Kronenberg 2018, Anguelovski et al. 2020). Such tensions are further exacerbated when cities become denser or gentrified, rewriting the scales relevant for accommodating different needs, as evidenced not least by restrictions on mobility and local recreation imposed by the COVID-19 pandemic (e.g., Honey-Rosés et al. 2021).

Drawing from several information sources for six case-study cities, Kronenberg et al. (2021) analyze investment and planning initiatives intended to make GBI benefits available and accessible to urban residents. They show how underappreciation of the complexity of social-ecological systems can lead to unintended consequences, trade-offs, and constraints in GBI planning, implementation, and management. Their findings provide arguments against a simplistic view that urban greening and blueing will unfailingly lead to positive results in terms of increased resident well-being. Instead, they argue that enabling the flow of benefits from GBI requires a thoughtful consideration of multiple issues, as they illustrate with the experiences in the case-study cities.

Examining one of the above case studies in more detail, in order to uncover potential barriers to the enjoyment of the ecosystem service benefits of local GBI, Haase et al. (2021) use mental mapping to explore place attachment in Halle-Neustadt, Germany. The study demonstrates how negative, unspoken place meanings and identities contribute to the non-use of urban GBI. Local GBI was completely absent from mental maps of recreational opportunities and spaces, an absence reflecting, the authors explain, neighborhood neglect and the multi-scalar character of urban recreational ideas/behavior.

Wolff et al. (2022) conceptualize and explore the barrier effects of interacting social-ecological-technological factors. The study uses a framework of physical, personal, and institutional barriers to analyze three case studies: Stockholm, Sweden; Leipzig, Germany; and Lodz, Poland. The authors argue that constrained access to GBI benefits is not the sum of universally consistent effects of interacting barriers. Instead, they point to the significance that beneficiaries assign to them, captured as perceived barrier effects. Grounded in this more comprehensive understanding of individuals' decisions in terms of accessing and realizing recreational benefits, the authors propose three complementary pathways for improving access to the recreational benefits of urban GBI: programming the environment, building knowledge, and supporting engagement.

Treglia et al. (2022) discuss green roofs as a strategy for converting often un- and underutilized and potentially problematic spaces into multifunctional parts of the landscape, using five boroughs of New York City, USA, as an example. The study demonstrates an implicit injustice: outside midtown and downtown Manhattan, most of the city districts, including areas that face stormwater management challenges and communities that are most vulnerable to impacts of heat waves, are comparatively underserved. The dataset developed, which is publicly available, can serve as a baseline for tracking change through time, while supporting further research, conversations, and policies related to the benefits and distribution of green roofs.

To link infrastructural and institutional factors to the flow of benefits from GBI, Łaskiewicz et al. (2022) study the accessibility of urban green spaces on the basis of urban morphology. They use the scale of individual buildings in five case study cities (Barcelona, Spain; Halle, Germany; Lodz, Poland; Oslo, Norway; and Stockholm, Sweden) to investigate the share of urban green spaces in the service area of 300 m walking distance from every residential building in each city. To account for institutional issues, the authors include property rights to indicate whether green

spaces are accessible to the public or not. The study highlights how locally specific combinations of urban morphology and ownership patterns create very different opportunities to benefit from green spaces.

Kraemer and Kabisch (2021) assess green space recreational quality on the basis of an indicator system detailing (1) natural elements, e.g., the types and configuration of vegetation and the proportion of water bodies; (2) built elements, e.g., various recreational facilities and path density; and (3) the embeddedness of green spaces within the built, social, and natural environment (context), e.g., the number of neighboring residents, nearby green or blue elements, and exposure to traffic. The study provides tools and guidance for identifying untapped potential for recreational activities, hindered by, for example, usage barriers, and balancing the trade-offs between benefits for human residents and biodiversity.

Now and into the unknown

Climate change, rapid and diverse urbanization (including both sprawl and shrinkage), shifting demographics, and lifestyle preferences all influence what we look to GBI to deliver, and the nature of GBI itself. In the face of rapid and often large-scale change, resilience has become a byword (Elmqvist et al. 2019, 2021, McPhearson et al. 2021). Although urban residents still depend largely on external support systems for their basic well-being (Seto et al. 2012, Friis and Nielsen 2019), some issues ask for local solutions. GBI, or the many different urban ecosystems, are a core asset for improving, mitigating, or reducing site-specific and often locally caused environmental burdens (particles, noise, waste, soil and water contamination, heat islands, flooding) and provide an attractive but sensitive setting for physical exercise (Tzoulas et al. 2007, van den Bosch and Sang 2017).

Shade et al. (2020) evaluate the implementation of a variety of GBI practices in Philadelphia, USA, intended to help meet state and federal stormwater regulations. To build resilience in pace with climate change, the authors demonstrate how the city government will need to expand its green infrastructure plan and consider the co-benefits of climate change adaptation when planning new projects. Additionally, the authors argue that for true climate change resilience to be achieved, green infrastructure implementation must be connected to citywide greening efforts and accelerate and continue beyond the near term for localities to function as they do today.

Starting with a review on GBI-relevant policies and co-development of scenario narratives of possible futures, De Luca et al. (2021) investigate the presence of resilience thinking in Barcelona's GBI-relevant policies. Building on this baseline, the study develops participatory scenarios and evaluates their implications for ecosystem service provision and overall strategies for dealing with change. Straddling research and practice, the study both supports the development of a comprehensive resilience strategy for Barcelona and indicates pathways for how other cities can sustain flows of ecosystem services.

Using the rapidly urbanizing landscape in Stockholm as a case, Borgström et al. (2021) apply resilience thinking to the urban context. Drawing on insights from the design and implementation of a participatory dialogue process, they explore the emergence

of landscape multifunctionality and how to deal with multiple drivers of change. Tracking and reflecting on the process as much as the outcomes, the article discusses resilience building in terms of stakeholder participation; the role of discourses, identities and mandates, agency, and adaptive capacity; and alternative strategies for dealing with change.

The study by Haase and Wolff (2021) identifies opportunities for regrowth and sustainable land development by applying the ecosystem services and green points frameworks to a set of land use transition rules. The study provides insights into how regrowth and greening can be reconciled in densifying neighborhoods and how effective and flexible different types of green spaces are in terms of the ecosystem services they provide. The results for the city of Halle show that ecosystem services benefit flows are likely to increase only in districts where real estate pressure is low, which may exacerbate injustices in terms of green space availability.

Andersson et al. (2021b) describe the outcomes of taking a case-sensitive, stepwise approach to finding foundations for resilience building. Three cases, Halle-Neustadt, Barcelona (De Luca et al. 2021), and Stockholm (Borgström et al. 2021), are evaluated and discussed in terms of outcomes and output, how they tried to make use of a shared conceptual framework, the challenges they faced, and what the outcomes were. This exploratory work points to a new way of engaging with urban resilience. The strength of the conceptual-methodological approach is that it is not limited to the identification of specific interventions or policy options, nor is it trying to prevent change; rather, it focuses on how to move with change and build resilience through the constant balancing of different types of social-ecological-technological change.

Learning (together) by doing

Inter- and transdisciplinary research projects bring with them both challenges and opportunities for learning among all stakeholders involved. This is a particularly relevant aspect in social-ecological research projects, which deal with complex, real-world systems and difficult problems involving various stakeholders' interests, needs, and views, while demanding expertise from a wide range of disciplines (Reed 2008, Cvitanovic et al. 2016, Freeth and Caniglia 2019). In theory, the value of GBI is widely appreciated, and keeping or making cities green has broad general societal support (as expressed, for example, by Sustainable Development Goal 11 [<https://sdgs.un.org/goals/goal11>]). However, the reality of fragmented and sectoral policy and planning, diverging economic interests, and often poor fit between the mandate, ambit, and resources of the many actors involved in creating and maintaining GBI make long-term provisioning of GBI benefits uncertain (Grunewald et al. 2021). Building resilience around GBI, and equitable flows of desired benefits, requires knowledge, both about what needs to be done and how it can be done. Dialogue and deliberative processes are gaining traction as (potentially) democratic and inclusive ways to handle the complex, context-sensitive nature of GBI well-being benefits (Mascarenhas et al. 2016, Hölscher et al. 2021). Yet these processes call for careful attention to a number of procedural aspects to ensure their fairness, validity, and actionability.

Mascarenhas et al. (2021) put forward an analytical framework for assessing the learning process of both the research team and

other participating stakeholders within the scope of an international transdisciplinary project dealing with urban green and blue infrastructure. The framework is structured around five dimensions of the learning process: “Why learn?” (the purpose of knowledge generation and sharing); “What to learn about?” (the types of knowledge involved); “Who to learn with?” (the actors involved); “How to learn?” (the methods and tools used); “When to learn?” (the timing of different stages). Applying the framework, Mascarenhas et al. illustrate how it can support reflexivity and capture the learning process taking place in transdisciplinary research more comprehensively than similar existing frameworks.

Borgström et al. (2021) argue that deep knowledge of the complexities of urban land use and governance requires the involvement of diverse stakeholders. However, handling this diversity poses a challenge for process design; combining the ambition of an inclusive process and the need to be relevant with the use of bridging concepts increases the risk of reducing the level of complexity of the deliberative process. There is also a risk of participation bias, where stakeholders knowledgeable about green-blue infrastructure are easier to engage compared with stakeholders with knowledge about drivers of change and urban governance, which will influence the system understanding and envisioned alternative pathways for taking action.

Pointing to the value of a shared conceptual system framework, Andersson et al. (2021a) describe how the combination of the three filters model (Andersson et al. 2019) and the ecosystem service cascade (Haines-Young and Potschin 2010) can guide and connect layers of inquiry and different epistemological approaches to building context-relevant knowledge, while allowing for flexibility for aligning with local circumstances. The study synthesizes insights from a set of exploratory case studies to outline pathways for gradually building a cumulative understanding across cases and city contexts. Many of the cases include different elements of participatory learning and alternative ways and different knowledges to draw on for answering similar questions. The article concludes by discussing key questions about GBI and how overall urban planning and governance can help ensure its contributions to urban quality of life.

In conclusion

Expanding the filters conceptualization, this special feature provides an operational framework and flexible epistemological approach for the complex questions that lie at the heart of urban social-ecological-technological studies. The articles in the special feature show the breadth, variety, and advantages of applying the filters approach. First, filters help to develop a differentiated understanding of when and how GBI has an influence on its urban context and thus matters for the quality of life of urban inhabitants (and vice versa). Inherently different dynamics and time scales make the filters relevant for discussing the interplay between slow and fast change, and between resilience and transformation.

Second, the filters framework, through its guidance for building deep, comprehensive case studies, helps to explore, understand, and make sense of the different range, sensitivity, and explanation power of applied methods both within cases and by comparing them. When intersected with other conceptualizations like

resilience, environmental justice, or GBI benefits, the filters framework offers a structure for connecting theories and analytical lenses. The articles of this special feature show how to untangle complexity and relate seemingly disconnected issues and thus provide depth to ideas like multifunctionality. Deep case understandings depend on the integration of different ways of understanding the system. The filters and their effects can be captured and portrayed with very different types of data and analytical approaches. As Mascarenhas et al. (2021) attest, how to weigh and combine evidence remains a challenge, in particular when diverse actors are involved. Finally, the iterative and reflexive way of studying and learning within the ENABLE project with respect to results, concepts, and methods has led to strong coalitions between local stakeholders and scholars, informed and driven by local settings and challenges, with a mutual knowledge gain for both groups.

Responses to this article can be read online at:

<https://www.ecologyandsociety.org/issues/responses.php/13580>

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