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Urban Green Infrastructure – Connecting People and Nature for Sustainable Cities[☆]

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Editorial

Urban green infrastructure (UGI) is a concept that has received wide attention in academia recently and is increasingly applied in practice (e.g. Ahern 2007, Mell, 2016, Pauleit et al. 2017, Rouse & Bunster-Ossa, 2013). UGI aims for the development of networks of green space that provide multiple benefits to people in the urban environment. Consequently, UGI should simultaneously serve to address major challenges of urbanisation such as an improvement of quality of life, social cohesion and environmental justice, protection of biodiversity, climate change adaptation and not least supporting the transition towards a green urban economy. In this sense, the notion of green as an infrastructure highlights the fact that urban green and blue spaces are crucial to the functioning of urban areas just as social and technical infrastructures are.

UGI can build on a long history of green space planning and has its antecedents in theories and applications of greenway and green structure planning, urban and landscape ecology, and more. Therefore, it has also been called a melting pot for innovative ideas (Hansen & Pauleit, 2014). Yet, whether and how UGI can make a substantial contribution to both sustainability and resilience of dynamically developing urban areas undergoing socio-demographic and economic change is still under debate. Can multifunctional networks of green and blue spaces be integrated into densifying and intensively used city centres to provide the ecosystem services needed for clean air, mitigating urban heat islands, reducing stormwater runoff, importantly enhance biodiversity and provide sufficient access to nature for human health and well-being? Do green façades and green roofs really make tall high-rise buildings more sustainable or are they just a form of green washing? Does UGI trigger the needed long-term transformation of urban areas and lead the way towards enhanced societal cohesion in the form of e.g. citizen engagement, re-empowerment and more environmental justice or is it just another technocratic approach to provide quick fixes to wicked urban problems (Lennon, 2014)?

Research projects at international and national levels have recently attempted to provide answers to these questions and advance the approach of UGI. In the member countries of the EU research has been boosted by the EU research programmes FP7 and Horizon 2020, and not least by new policy on Green Infrastructure (EC, 2013). In its current research programme Horizon 2020, EU continues to support research on UGI embedded into the term of Nature-based Solutions (NbS). These transnational research and networking initiatives as well as initiatives at national level in Europe are complemented by a variety

of research globally with particular strongholds in North America, Australia and increasingly in China (Elmqvist et al., 2018).

The EU FP7 funded project *GREEN SURGE* (2013-2017, www.greensurge.eu) aimed to develop a better evidence base, methods and tools to enhance understanding of the linkages between people and biodiversity in urban areas, assess the functions and ecosystem services of UGI, test novel methods for social and economic valuation of UGI, and identify advanced approaches for UGI planning and governance. The guest editors of this SI have all been involved in this project and several contributions to this SI offer results and reflections from *GREEN SURGE*.

Literature on UGI is growing fast. Publications are dealing with specific functions of UGI such as its capacity to mitigate the urban heat island effect, preserve and enhance biodiversity, etc., providing new evidence, presenting methodological approaches but also dealing with the arena of policy-making. The aim of this SI is to critically discuss UGI, its theoretical foundations, as well as the evidence base, methods, and policies, as a necessary prerequisite to clearly outline priorities for future development of the concept and its implementation. In this context, this SI intends to:

- Provide novel insights into the value of the UGI concept from recent research, covering a broad range of policy themes (such as climate change adaptation, biodiversity protection, increasing social cohesion and human health as well as supporting the green economy).
- Contribute to the advancement of the theoretical foundations of UGI as a planning and governance approach, and related novel and innovative concepts and approaches such as biocultural diversity, and ecosystem services and their valuation.
- Explore advances in the practice of UGI usage, governance and planning.
- Outline future directions for advancing UGI as a concept and a practice.

The final conference of *GREEN SURGE*, Malmö, 20-22 September 2017, that brought together a great number of researchers and practitioners from all over the world was the point of departure for this SI. Consequently, a call for contributions was made that resulted in an amazingly large number of not less than 33 papers accepted for publication. They can be taken as a sign to the vigour of the UGI concept both in science and in practice. Included are papers from studies that address certain functions of UGI such as improving thermal comfort and that aim to unravel the ecological processes that are underlying these functions. In addition, specific types of UGI such as green roofs or trees are in focus of a range of papers presenting new empirical knowledge. However, the much larger part of the papers are concerned with issues related to the governance and management of UGI, methods and tools, e.g. to assess its perception, use and for valuation, presenting empirical findings as well as conceptual advancements with evidence from many different cities. Not least, some papers explore the relationships between certain GI elements such as trees and green roofs and environmental and social processes such as stormwater runoff, thermal environment and user perception. While the majority of the papers is the result of research undertaken in the Western world (in particular Europe), it should be highlighted that there are also papers from China, Bangladesh and Latin America dealing with issues of relevance in these regions such as green infrastructure in Brazilian Favelas or green retrofitting in Chinese megacities. A small number of papers also explicitly deals with aspects of biodiversity but a systematic attempt to approach biodiversity of UGI in cities is still waiting for scientific study, a challenge beyond this SI.

Given the size and diversity of this SI, no attempt is made to draw all-encompassing conclusions. However, from the insights gained in the *GREEN SURGE* project, we are convinced that UGI is a valuable concept that can advance the current practice of urban greening and make a significant contribution to the transformation of urban areas towards their sustainability and resilience. It also enriches our scientific and factual knowledge about UGI as a whole and on specific types of UGI.

GREEN SURGE has revealed a wealth of activities ongoing in cities across Europe to develop quality green spaces by government-led planning as well as citizen-led initiatives. Clearly, for all of the cities, green space is important, even though great differences were observed due to different demand on green space, a wide span of availability of resources, diverging planning cultures, etc. Moreover, we found evidence that there is acquaintance with and agreement on underlying thinking and principles of UGI e.g. of creating well-connected and multifunctional green spaces within cities and with the surrounding landscape. However, their uptake in practice is often partial and more related to actual challenges, e.g. in response to the increasing experience of heat waves, rather than guiding comprehensive green planning. Perhaps the greatest need for improvement concerns a better inclusion of citizens in the making and in the stewardship of UGI. As a foundation, there is also a need to better understand human – nature relationships in urban areas, accounting for both the biological diversity as well as the diversity of people with their different socio-cultural backgrounds and attitudes to nature in the city. Here, the SI makes valuable contributions with papers dealing with the biocultural diversity in its materialized, lived and managed form for parks, brownfields and gardens. Not least, there generally is a lack of monitoring of urban green and the ecosystem services it can provide. Latest remote sensing based green monitoring approaches (data, processing and indicators) (Wellmann et al., 2017) are beyond this SI. Similarly, the values of UGI need to be assessed for its mainstreaming into urban policy making. As economic valuation alone cannot represent the full spectrum of ecological, social and cultural meanings of UGI, integrated approaches to valuation should combine different methods of valuation in meaningful ways and at different spatial-temporal scales.

Therefore, there still is significant scope for the advancement of current practice when mirrored against principles, methods and tools of urban green infrastructure planning and governance. However, in cities representing all of Europe's regions examples of good practice could be identified which, distilled into handbooks, can serve as an inspiration for enhanced development of UGI. Importantly, the good cooperation between practitioners from five cities and the researchers in the setting of *Urban Learning Labs* and *Focal Learning Alliances* offered significant added value to both parties by mutual knowledge exchange and joint learning. These "living lab" approaches should be further promoted but in the *GREEN SURGE* we also learned that successfully organising such platforms is a great challenge in the tight frames of relatively short-term projects and they clearly seek for a longer term perspective after a project's end. Moreover, it is not easy to reconcile the different expectations of practitioners and researchers which may be simply put as 'political success' vs. 'scientific papers' but the joint face-to-face discussion proved to be crucial also in this project. Consequently, experience made in the current wave of 'urban lab' projects should be carefully reflected to create the necessary conditions for transdisciplinary projects on UGI.

In conclusion, urban green infrastructure is crucial for urban liveability, sustainability and resilience. This SI is a proof to its strength as a foundational concept and inspiration for research and advanced practice. Addressing the huge challenges of global urbanisation - close to 7 billion people are expected to live in urban areas by 2050 (UN 2018) - strongly calls for the further development of urban green infrastructure in different urban contexts. The cities of the Global South should be a particular focus area for such work as 90% of urban growth is happening there. Research and practice should be based in an understanding of urban areas as social-ecological-technical systems (Depietri and McPhearson, 2018) to integrate the respective disciplines with their wisdom on ecological processes, human agency, and smart engineering. Moreover, awareness of the biocultural diversity of cities as well as the development of novel ways for effective governance are needed with the ongoing cultural, social and economic diversification of cities across the globe. Developing urban green infrastructure for the future will therefore require novel ways for inter- und transdisciplinary working that we have only started to explore.

Stephan Pauleit, Erik Andersson, Barbara Anton, Arjen Buijs, Dagmar Haase, Rieke Hansen, Ingo Kowarik, Jari Niemelä, Anton Stahl Olafsson, and Sander Van der Jagt.

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