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Review

Advancing urban green infrastructure in Europe: Outcomes and reflections from the GREEN SURGE project☆

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ABSTRACT

Urban green infrastructure (UGI) is a promising concept when developing multifunctional green space systems to address major challenges of urbanization such as increasing social cohesion, promoting the transition to a green economy, adaptation to climate change and conservation of biodiversity. In response to the European Commission's Communication on Green Infrastructure from 2013, the GREEN SURGE project aimed to further advance the development of UGI in European cities by (i) strengthening the conceptual foundations of UGI, (ii) developing improved methods and tools for assessment of its state, benefits and governance and, (iii) applying these to build a stronger evidence base. This paper aims to provide an overall synthesis of the project's main achievements.

GREEN SURGE adopted an inter- and transdisciplinary approach. Urban Learning Labs and focal Learning Alliances in five cities were instrumental for intensive collaboration between disciplines and across science and practice. Pan-European surveys, e.g. of planning and governance practice or human-nature interactions established the state-of-the-art across the continent and identified good practices.

The project consolidated green infrastructure planning and governance conceptually, and it mapped opportunities for better linking government-led planning with bottom-up initiatives for creating and managing UGI. It also introduced a framework for knowledge integration to support UGI valuation. Importantly, development and application of the concept of biocultural diversity gave new insights into human–nature relationships in

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multicultural urban societies. The results strongly call for more context-sensitive development of UGI that addresses the different needs and diverse cultural practices of people engaging with nature.

In a nutshell, GREEN SURGE showed that UGI indeed can make a major contribution to sustainable and resilient urbanisation. Transdisciplinary research in urban labs, if well-conceived, has shown to hold great potential to advance UGI concepts, methods, knowledge and practice.

1. Introduction

Urban green infrastructure (UGI) offers a gateway to urban sustainability. UGI is understood as both multifunctional networks of green and blue spaces and the processes that govern its development (Ahern, 2007; Benedict and McMahon, 2006; Mell, 2016; Pauleit et al., 2011). It has the potential to make substantial contributions to meet policy objectives for improving public health, providing opportunities for recreation, enhancing social cohesion, supporting the local economy, protecting biodiversity, and helping cities adapt to a changing climate (Pauleit et al., 2017). There is increasing evidence on the cost savings and additional benefits that UGI can provide over, but also complementary to, conventional 'grey' approaches, e.g. when it comes to stormwater management and cooling of cities (Elmqvist et al., 2015; Jayasooriya and Ng, 2014). UGI may also support the less tangible aspects of sustainability, such as serving as a platform for knowledge co-creation, for engaging with social justice issues and inclusivity, and for testing new, more comprehensive governance strategies (Haase et al., 2017).

There is a growing understanding of the potential of UGI and strong interest at all levels of government. Within Europe, the European Commission's *Communication on Green Infrastructure,* which acknowledged the important functions and services of green spaces and formulated aims to mainstream green infrastructure into EU policy areas, has been key for promoting the uptake of the green infrastructure concept (European Commission, 2013).

Despite this, there are still significant barriers to the wider uptake of UGI. Important obstacles are physical constraints, low attentiveness of the planning system and other legal frameworks to UGI, a lack of discourses and champions supporting UGI, path dependency of institutions connected to the lack of human resources, limited awareness, knowledge and influence of professionals, and fiscal constraints (Byrne and Yang, 2009; Dodson, 2009; Grădinaru and Hersperger, 2018; Kambites and Owen, 2006; Matthews et al., 2015; Rall et al., 2015). Knowledge and data about the status of green and blue spaces in Europe's urban areas and their functional linkages to ecosystem services (ES) is also insufficient. While there is some comparative information on the provision and dynamics of green spaces in urban areas at the European level (Fuller and Gaston, 2009; Kabisch and Haase, 2012), this does not distinguish between different types of green spaces and there is a lack of understanding of the differential benefits that people gain from these. Also, there still is a need to provide better tools for mapping the supply and demand of these ES, especially cultural services (Haase et al., 2014).

The need to better account for diverse values associated with ES and the biodiversity of urban green spaces is a particular challenge. New methods are required, and the ones already existing need to be adjusted to better join stakeholder views and relational values with the economic implications of green spaces (Kronenberg and Andersson, 2016). Most studies on the economic values of green space have relied on only one method for valuation such as hedonic pricing or contingent valuation while focusing on a narrow range of ES such as recreation (e.g. Czembrowski and Kronenberg, 2016; Tyrväinen and Väänänen, 1998), indicating that the field needs to expand.

Moreover, there is a strong need to support planning and governance of UGI at the local level, where more comprehensive guidance is required (Tzoulas et al., 2007; van Oudenhoven et al., 2012). Previous research and scientific networks have shown the potential of pan-European studies to generate insights into successful strategies for green space planning and management (e.g. Smaniotto Costa et al., 2008; Werquin et al., 2005) but do not refer to the UGI concept.

In all, the intricate relationships between ecological, socio-cultural and governance dynamics relevant to UGI are still poorly understood (Buizer et al., 2016; Kabisch et al., 2014). Our knowledge about innovative practices, especially bottom-up initiatives with their respective actors and how these align with or complement government-led planning activities, is still scarce. This emphasizes the need for transdisciplinary approaches to better understand opportunities and constraints within fields of practice, including the awareness, knowledge, motivation, mandates and commitments of a large range of actors (Butterworth et al., 2011).

The EU has dedicated substantial funding for research and development projects on UGI, and more recently for the related concept of nature-based solutions (NBS) (European Commission, 2015), to address these deficits. In this context, the GREEN SURGE project received funding from 2013 to 2017 to further develop the conceptual foundations and evidence base of UGI, identify suitable approaches for planning and governance, and further the valuation and market integration of biodiversity and ES provided by UGI.

In this paper, we aim to synthesise main insights from GREEN SURGE related to (a) the development and application of an inter- and transdisciplinary approach acting to connect different scientific disciplines and practice; (b) the assessment of the current situation of UGI across Europe's urban areas and how this relates to human benefits; (c) the provision of a better understanding of the reciprocal relationships between urban nature and human society, (d) the development of integrated approaches to the valuation of UGI which are able to capture the multiple perspectives on urban green and blue spaces, and (e) the identification of innovative strategies for UGI planning and governance. The paper will conclude with a reflection on the status and prospects of the UGI approach to identify challenges for its future development in science and practice.

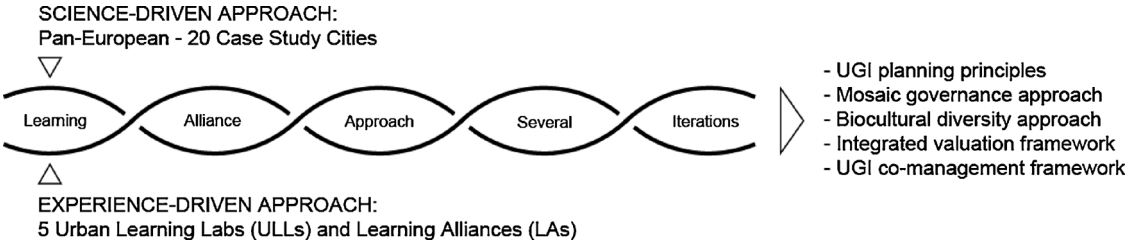

Fig. 1. The "double helix" approach for transdisciplinary research and learning adopted in the GREEN SURGE project with main conceptual outputs. Courtesy of T.S. Vrhovnik and R. Cvejić.

2. The GREEN SURGE approach to knowledge co-creation

The GREEN SURGE project applied a transdisciplinary "double-helix" approach to analyze the linkages between urban green and blue spaces, their biodiversity and ES, and local planning and governance mechanisms (Fig. 1; van der Jagt et al., 2015). The approach was characterized by a multilevel research design consisting of a combination of European and local level study (Fig. 2). Moreover, quantitative and spatial approaches, e.g. to analyze the linkages between green space and biodiversity, were combined with qualitative and action-oriented approaches to analyze planning and governance of UGI.

To facilitate an iterative process of knowledge exchange, we applied the focal Learning Alliances (LA) approach as a tool for knowledge co-production around complex resource management challenges (e.g. Verhagen et al., 2008). LAs are characterized by engaging a stable, defined group of stakeholders from different backgrounds in a process of co-learning with regularly scheduled meetings. In GREEN SURGE, LAs were established in five European cities selected to cover a range of planning cultures, urban growth patterns, levels of per capita urban green space provision and urban density levels: Bari (Italy), Berlin (Germany), Edinburgh (United Kingdom), Ljubljana (Slovenia) and Malmö (Sweden). To support long-term engagement, city officials and other local stakeholders developed shared goals and objectives (e.g., a demonstration project) which varied from improving school children's connection to healthy produce in Berlin (Fischer et al., 2018a), to mapping priority areas for green infrastructure development in Edinburgh (Bellamy et al., 2017).

Urban Learning Labs (ULLs) were launched to work *in tandem* with LAs to facilitate connectivity with other networks in the city and to engage in knowledge dissemination on broader UGI-related topics (see Fig. 3). Unlike LAs, they operated on an irregular schedule and engaged a varied group of stakeholders depending on the selected topic of the ULL meetings. A total of 29 ULL workshops and events were organized in the five ULL cities with meeting topics varying from integrated UGI valuation to UGI planning and co-governance (van der Jagt et al., 2017a).

A systematic, stepwise process was taken towards identifying relevant stakeholders and shared topics of interest, and process monitoring. To support this process, we developed a framework including: 1) a ULL matrix to explore relevant UGI initiatives, policy instruments and associated stakeholders, 2) a Mind Map to explore relationships with research themes, 3) a Stakeholder Salience Analysis to explore which stakeholders are more or less relevant to engage, and 4) a Stakeholder Monitoring Graph to identify a representative group of stakeholders, set collaborative learning objectives and monitor adaptive capacity over time (Smith et al., 2015; Van der Jagt et al., 2018). The stakeholder engagement process was moderated professionally.

An important limitation of co-learning projects at the science-policy interface is that they have been poorly monitored and evaluated (van Herk et al., 2011). Therefore, in the final stage of the project, the GREEN SURGE consortium evaluated the LA process to capture its outcomes and to share lessons around orchestrating the double-helix process (van der Jagt et al., 2017a). This evaluation focused on different kinds of process outcomes varying from cultural change to new

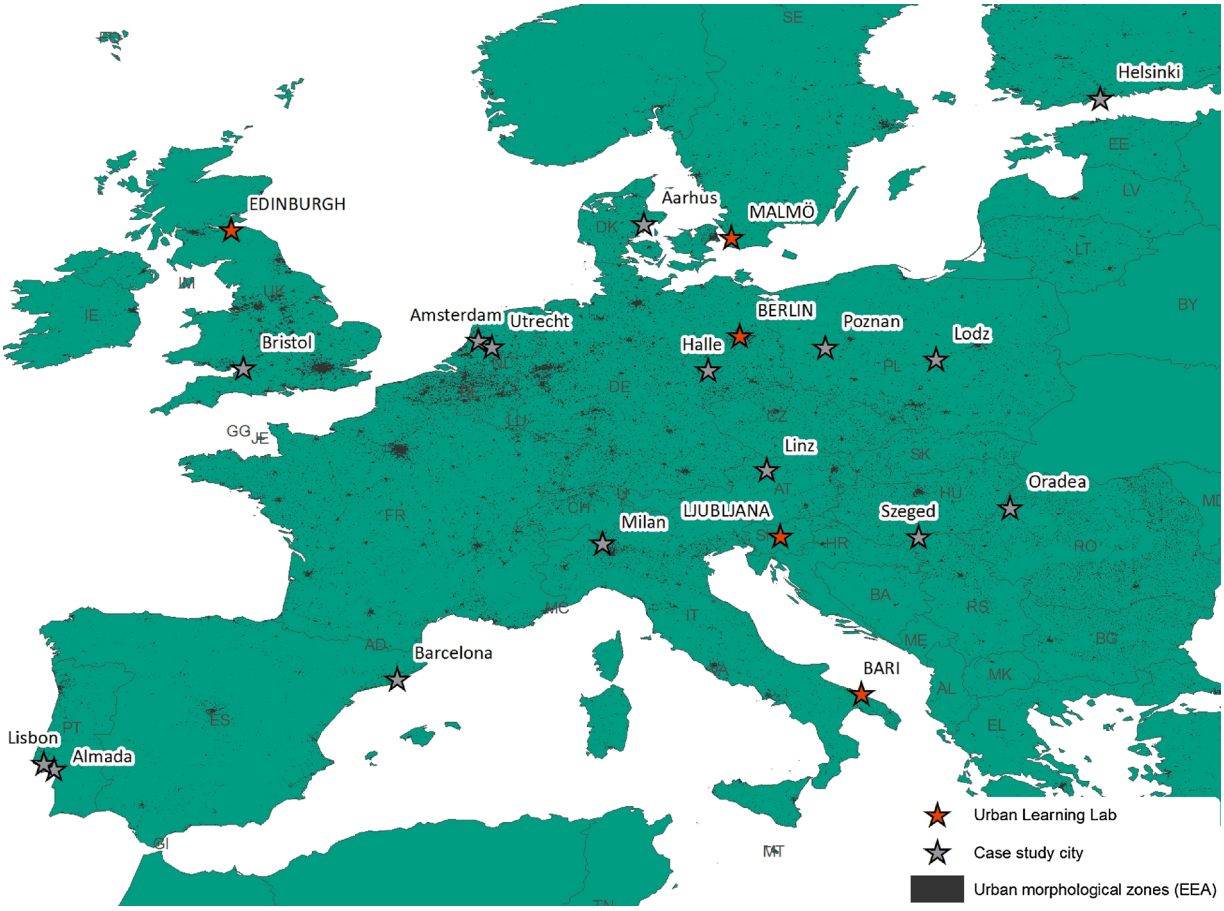

Fig. 2. GREEN SURGE Case study cities and Urban Learning Labs.

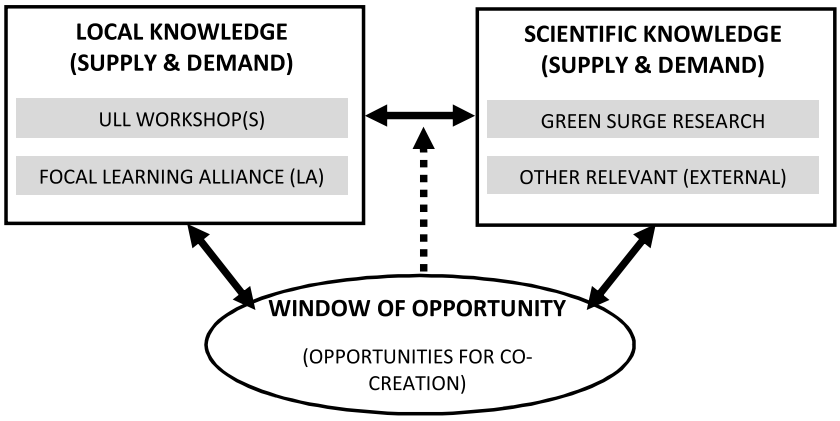

Fig. 3. Diagram showing the dynamic and continuous process of distilling the key opportunities for knowledge integration within the GREEN SURGE project. Experience-driven knowledge gained at Urban Learning Lab (ULL) workshops and Learning Alliance (LA) meetings is shared with the research consortium, while scientific knowledge from the consortium is disseminated to local ULL and LA stakeholders. Knowledge is exchanged and experiments are undertaken around particular themes and challenges that benefit from knowledge exchange between local stakeholders and scientists; this 'window of opportunity' is different for each LA. The envisioned end-result is a strengthened link and more targeted and effective exchange between local and scientific knowledge (dotted arrow).

policies and provided recommendations on transdisciplinary working to both cities and researchers.

3. Urban Green Infrastructure and ecosystem services in European cities – developing a typology and the evidence

One of the objectives of GREEN SURGE was the development of a sound evidence base, which links green elements of urban nature, ES and current European land cover/use datasets in cities with the way they are planned, designed and managed (Vierikko et al., 2016). The development of a UGI typology demonstrated the great variety of green space types across European cities and resulted in 44 urban green types clustered in eight groups (Fig. 4) which is considerably more comprehensive than other UGI typologies (Koc et al., 2017) and provides an

Fig. 4. UGI typology as developed in GREEN SURGE.
Source: Hansen et al. (2017b), design by E. Chapman, photos by R. Hansen; courtesy of GREEN SURGE.

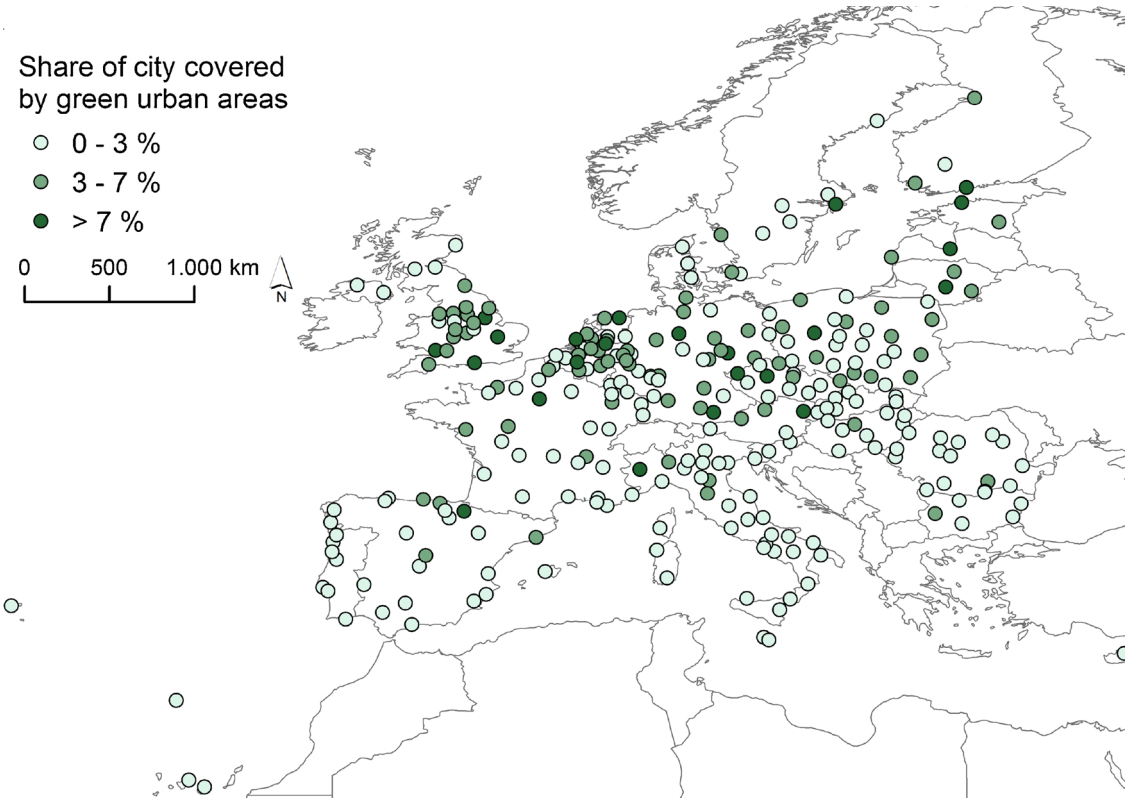

Fig. 5. Share of city areas covered by public green urban areas, predominantly parks. Calculation based on Urban Atlas data (N = 299) (EEA, 2017). Source: Cvejić et al. (2015); courtesy of GREEN SURGE.

entrance point for assessing ES specifically for UGI types, e.g. public parks (Kabisch et al., 2016a,b).

For an overview of the amount of UGI as a whole and of specific UGI types in European cities, we quantified some of the most important and most frequent UGI types using European-wide Urban Atlas data (EEA, 2017; Fig. 5) and combined these with population data at 1 km^2 resolution (for details see: Cvejić et al., 2015). Results gave new insights into differences of overall urban green space cover and that of individual UGI types such as public parks, forests and residential green spaces for geographical regions in Europe (Cvejić et al., 2015; Kabisch et al., 2016a). Availability of green spaces close to where people are living was much lower in urban areas of Southern and South Eastern Europe when compared to Scandinavian countries or in Western Europe (Fig. 6). A possible explanation may be that South Eastern European cities have lacked sound green space management after their entry into the market economy and experienced a new construction boom, which has dominated recent land development (Kronenberg, 2015). For the first time, GREEN SURGE produced a pan-European map for such a large sample of European cities, applying a distance model to assess availability and thus also the demand-supply relationship of specific green space types such as public parks and their recreation ES (Kabisch et al., 2016a).

Regarding innovative UGI types, a literature review revealed that only large cities actively pursue vertical greening strategies (Haase et al., 2017). Communal gardens are very common across all cities and types include small allotment gardens and different forms of community and intercultural gardens where, next to the ES of local production of food, also enhancement of social cohesion is an important goal (Elands et al., 2018; van der Jagt et al., 2017b; Vierikko et al., 2017) which provides novel evidence of the close link between UGI and human well-being, but, primarily through specific UGI types and not through the whole urban UGI.

A review of the literature also provided detailed information about more functional linkages between the UGI types identified in GREENSURGE, specific ES they provide and again specific human health effects, including synergies, trade-offs and spatial patterns, furthermore depending on size and state of the UGI types (Haase et al., 2016). In addition, empirical studies in the ULLs provided evidence of selected ES for UGI types (Jagt et al., in press). For instance, results showed that forests and tree-rich parks provide cooling and a decrease of land surface temperature most effectively (Weber et al., 2014).

Further study concentrated on the assessment of cultural urban ES where knowledge gaps are particularly large (Haase et al., 2014). Participatory approaches to assess green space perceptions and uses such as public participatory geographic information systems (PPGIS) were tested in selected ULLs, showing that not only public parks and gardens are frequented by urban residents for different forms of recreation (Fischer et al., 2018b; Rall et al., 2017; Vierikko et al., 2017), but also green spaces not part of the public green space system such as urban wastelands or brownfields are important for specific recreation activities such as walking the dog or hanging around (Püffel et al., 2018). PPGIS also allowed identification of green spaces in need of better management due to overcrowding, neglect, littering, etc. (Rall et al., 2017). In another study, particularly elderly people were found to make use of the multiple ES that urban allotment gardens, another UGI type of the GREENSURGE typology, provide, which include provisioning services alongside recreation, fresh air and landscape aesthetics (Kabisch et al., 2014). This finding is important as knowledge about the recreational behaviour of the urban elderly, an increasingly large group in European cities, is limited (Sugiyama et al., 2009).

4. Relationships between humans and nature in cities: Biocultural diversity

Research on urban biodiversity and its functions has greatly advanced in recent decades (McPhearson et al., 2016). Human factors

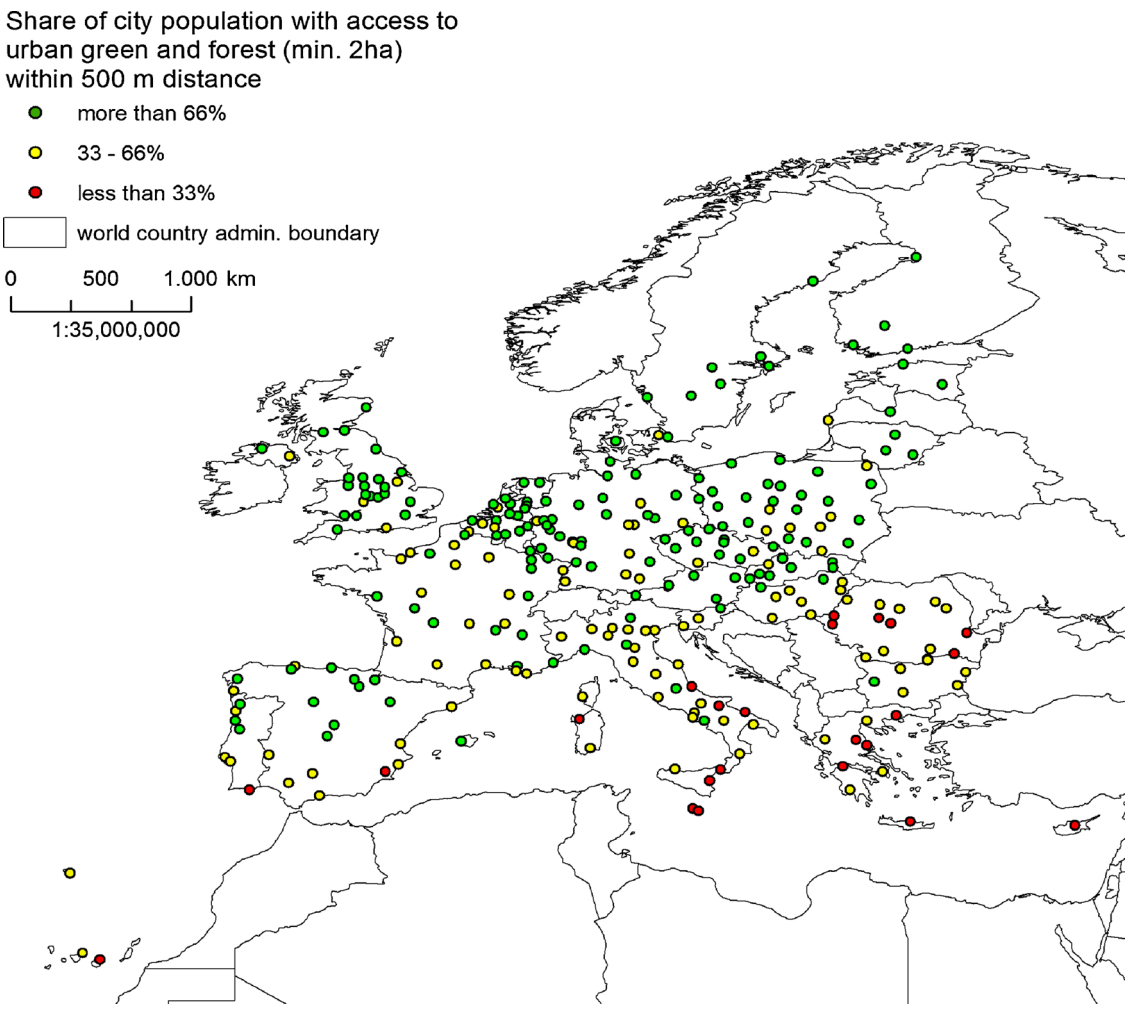

Fig. 6. Share of population with urban green space (≥2 ha) available within 500 m in administrative city boundaries. Note: Calculation based on GEOSTAT 1 km² grid and Urban Atlas land cover data (N = 299).
Source: Cvejić et al. (2015); courtesy of GREEN SURGE.

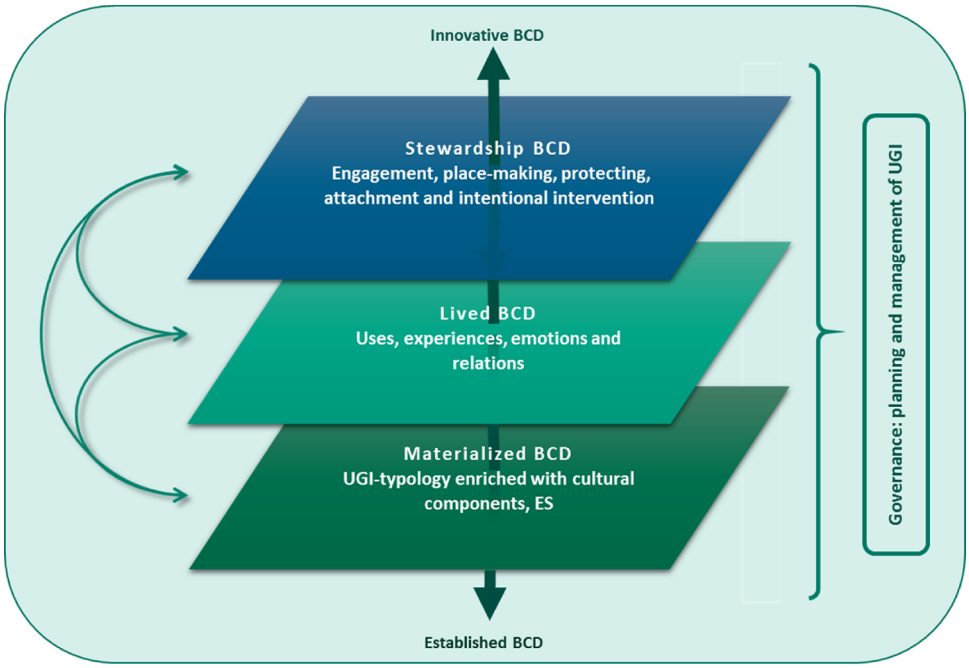

Fig. 7. Conceptual framework for the study on and governance of biocultural diversity in cities (Elands et al., 2018).

such as land use and green space management have shown to be key determinants of the various expressions of urban biodiversity. However, what has received less attention in such research is the fact that human society can be also extremely diverse in urban areas in terms of their perception of urban nature, their motivations to engage and their approaches to shaping urban nature – either purposefully or coincidentally.

In this context, GREEN SURGE developed a biocultural diversity (BCD) framework for urban environments (Elands et al., 2018). The conceptual framework provides three dimensions for studying intrinsically linked human-nature relationships—lived, materialized and stewardship BCD. At the heart of the framework is lived BCD, which expresses the day-to-day practices and experiences of people interacting with green places, involving e.g. use, emotions, and feelings of belonging. Materialized BCD refers to the tangible manifestation of these interactions, both physically (parks, communal gardens, etc.) and conceptually (contents of management plans, ES, etc.). Stewardship BCD, finally, includes all forms of engagement in which people take responsibility for the design and management of green areas (Fig. 7). An understanding of these interlinked dimensions of BCD may help envision how future stewardship can be supported (Buizer et al., 2016; Vierikko et al., 2016).

Applying this concept, we analyzed how current European urban policy and management addresses BCD (Elands et al., 2015). When policy-makers of 20 European cities were asked whether their city had formal urban green policies which explicitly recognized and accommodated the uses, needs and values of different cultural groups, the majority did not confirm this (Fig. 8). Cultural diversity was interpreted in terms of recreational needs, access for all and cultural heritage, whereas identity and cultural dynamics did not play a significant role.

As important knowledge gaps exist around understanding how culturally diverse people in urban societies perceive, value and use biodiversity (Botzat et al., 2016), we performed a range of BCD studies in European cities. A cross-case survey in the five ULL cities (Fig. 2) demonstrated that people largely prefer high plant species richness in parks, wastelands, and streetscapes and believe that high biodiversity supports more livable cities. However, considerable variation existed among cities and sociocultural groups. Park uses varied among sociocultural groups, e.g. between people with and without a migrant background. Yet, differences found for the first generation seem to diminish in the following generations, indicating that adolescents are more likely to adapt to local recreational patterns than the previous generation (Fischer et al., 2018c). Overall, the study demonstrates that biodiverse green spaces provide added value over simply green spaces (Fischer et al., 2018c). However, a study in Łódź, Poland indicated that more bioculturally diverse greenspaces are not necessarily also more valuable in monetary terms (Czembrowski et al., 2016b).

A study in Helsinki, Berlin and Bucharest showed that parks reflect the social identity of urban neighborhoods, and a weak social capital or a negative perception of the area can decrease the ability of its parks to promote social cohesion (Vierikko et al., 2017).

Finally, a study on stewardship BCD in urban farming projects and allotment gardens assessed how the actors express and acknowledge biodiversity and whether a strong bonding with nature has evolved (Vierikko et al., 2016). Results highlight the role of such green spaces as places for engagement and social cohesion. The potential pitfall, however, is that these highly engaged communities become protective of their place, thereby hindering other cultural groups to participate, which could decrease the social cohesion of the neighborhood.

5. Towards a green economy: multiple perspectives on the value of UGI

GREEN SURGE defined green economy in broad terms as an economy that aims to improve human well-being and social equity while significantly reducing environmental risks and ecological scarcities (UNEP, 2011). In line with the above, GREEN SURGE set out to investigate how a better articulation of UGI values (i.e. with a particular focus on connected mosaics of different green spaces) might open up for new combinations of different resources and actor contracts, and thus help ensure that a green economy can be an integral part of an interconnected social-ecological system. At larger scales, functional connections and more diverse types of green spaces create new opportunities and impose new challenges simply by diversifying the group of potential beneficiaries and investors. The complex character of urban mosaics means multiple potential pairings of land-covers, land-uses and landowners (cf. Colding, 2007), which points to the need for coordination, collaboration and dialogue about values. This is further compounded by the fact that value is most commonly an outcome of the combination of bundles of ES in combination with amenities (e.g. play grounds, cafés, infrastructure for walking or cycling). The latter often hide the contribution of ES when putting a value on the total experience.

Studies within GREEN SURGE focused on narrow economic benefits and values related to UGI as well as broader, more inclusive approaches to valuation. As one of the primary examples of the first, and building on a study of the costs and benefits of urban forestry conservation and restoration projects, Elmqvist et al. (2015) concluded that ecological restoration and rehabilitation of ecosystems such as rivers, wetlands, lakes, and woodlands, was not only ecologically and socially desirable,

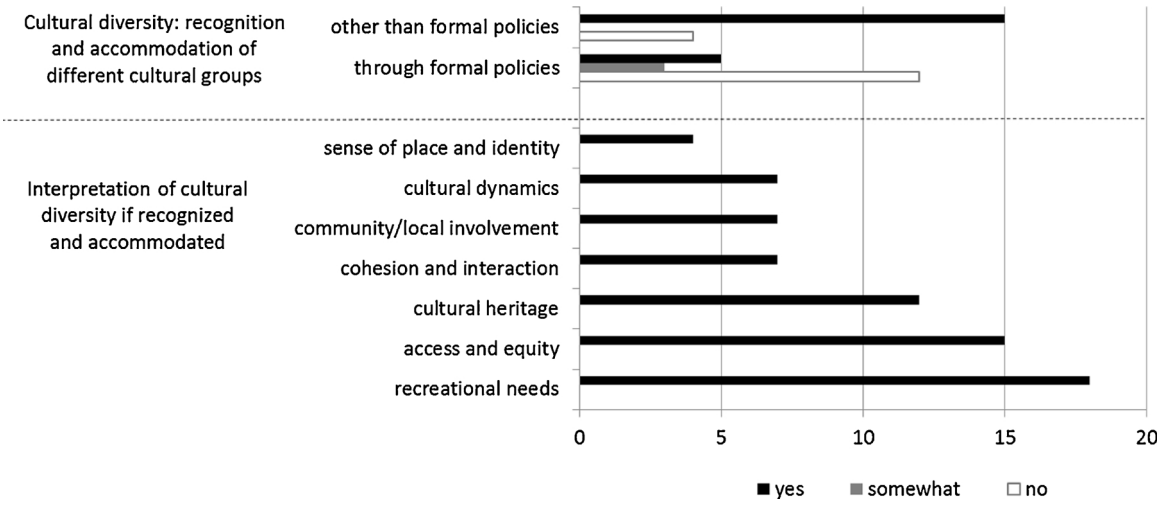

Fig. 8. Interpretations of cultural diversity in European cities (N = 20) (Elands et al., 2015: 3356).

but also, quite often, economically advantageous. The analyzed ecosystems were estimated to provide between $3212–17,772 (USD) worth of benefits per ha per year, based on only five different ES (local pollution removal, carbon sequestration and storage, regulating water flows, climate regulation/cooling effects, and aesthetics, recreation and other amenities) (ibid).

From several hedonic pricing studies (Czembrowski et al., 2016a, 2016b; Czembrowski and Kronenberg, 2016) we know that people are willing to pay for the general attractiveness of green spaces, and that this attractiveness is influenced by many different factors and values (Voigt et al., 2014). These values may or may not be reflected in housing prices but our ability to ask questions about how different value dimensions connect and come together allows us to examine problems not only from the dominant economic perspective (Hubacek and Kronenberg, 2013; Martín-López et al., 2014). One of the major contributions of GREEN SURGE was the development of a framework (Fig. 9) for how to think about integrated valuation (Kronenberg and Andersson, 2016). The framework focuses on whether or not value dimensions are commensurable, i.e. they can be meaningfully related to or compared to each other, and whether the methods are technically compatible (ibid). The framework offers information on both limitations and uses of different degrees of integration of many frequently used valuation methods (Kronenberg et al., 2017).

Finally, the processes of creating, restoring or maintaining UGI point to the many different funding sources, actors and roles involved in and necessary for ensuring UGI solutions in cities. Andersson et al. (2016) and Ambrose-Oji et al. (2017) illustrated the many different opportunities for local businesses and other commercial interests to be involved in and benefit from UGI. Using an example from the UK, Andersson et al. (2015) showed how complex mosaics of different types of green and blue spaces open up different possibilities for businesses to get involved. In addition to new niches and job opportunities there are also many 'positive externalities' that businesses may benefit from, like people being attracted to, and spending more time in and near, green spaces (Brengman et al., 2012). Sometimes these are recognised, but the 'internalisation' seems to be limited (Andersson et al., 2016).

6. Innovative urban green infrastructure planning and governance

Over the years, several approaches to UGI planning have emerged (Kambites and Owen, 2006; Pauleit et al., 2011; Rouse and Bunster-Ossa, 2013). In GREEN SURGE, we compared theoretical approaches to UGI planning with actual planning practices in 20 cities across Europe. This analysis showed that strategic planning of UGI holds potential to target pressing issues such as climate change adaptation and societal cohesion, and to move from sector-oriented planning towards more holistic approaches (Davies et al., 2015). This work was supplemented with 14 in-depth case studies of good practices (Hansen et al., 2016). Combining these analyzes, GREEN SURGE established a holistic but concise UGI planning scheme with four core planning principles: green-grey integration, connectivity, multifunctionality, and social inclusion (Fig. 10).

Through the ULLs, our work was discussed with planning practitioners from different European cities as a way to validate the concepts and understand more about barriers to practice. Examples of debates included the operationalization of multifunctionality, the role of peri-urban agricultural land as part of the UGI or the potentials of PPGIS (Hansen et al., 2017a; Rolf et al., 2018; Rall et al., 2018; Møller et al., 2018). Important factors of success for integrated UGI planning include the capacity to collaborate across disciplines and sectors but also a coordinated mix of different strategic planning instruments and implementation mechanisms such as spatial assessments, strategic measures and monitoring (Hansen et al., 2017b, 2016).

Besides strategic planning from local governments, our work highlighted that non-state actors such as NGOs, active citizens and social enterprises also contribute significantly to UGI. Case studies in 20 cities showed that there is a wide variety of co-existing governance arrangements through which governmental and non-governmental actors engage in UGI creation, maintenance and decision making (Buizer et al., 2015; van der Jagt et al., 2016). A typology to characterize and understand the range of collaborations between governmental and non-state actors was developed based on 18 in-depth empirical studies (Fig. 11). For each of these types of green space governance, good practice examples were identified, which showed how involvement of non-governmental actors in planning and governance can contribute towards social and environmental values.

7. Discussion and conclusions

GREEN SURGE provided a unique opportunity to bring together different disciplines in a large consortium to advance the theoretical framing of UGI, improve its evidence base, and identify tools and strategies for successfully integrating UGI in European cities. The UGI concept thus offers important venues for creating synergies and new linkages between environmental, social and economic sectors. The following discussion reflects on the main outcomes and the underlying overall research approach to condense some insights for future studies and urban practice.

7.1. Conceptual advances

Green infrastructure is an ambiguous term that has been interpreted and applied differently (Pauleit et al., 2017). Certainly, the concept's broad scope is supportive to its uptake in various contexts, but it risks being merely used as a new label to current practice without advancing it. In this respect, the synthesis of core principles and objectives (Fig. 9) provides guidelines for innovative UGI planning that still can be flexibly adapted to different purposes in various planning contexts. Combining and applying these principles in concert makes UGI a distinctive approach that holds great potential to advance the current practice of green space planning in Europe, as our analysis of 20 urban areas has shown.

Concurrently, GREEN SURGE has advanced our understanding of the diversity of bottom-up initiatives that create and manage urban green spaces for a variety of reasons. As shown, these initiatives have a high potential to contribute to the development of UGI (i.e., especially multifunctionality and social inclusion), while also improving peoples' connection with their urban environment (Mattijssen et al., 2018; Van der Jagt et al., 2017b, 2017c). Moreover, a specific actor type may play different roles in different initiatives, and acknowledging and making

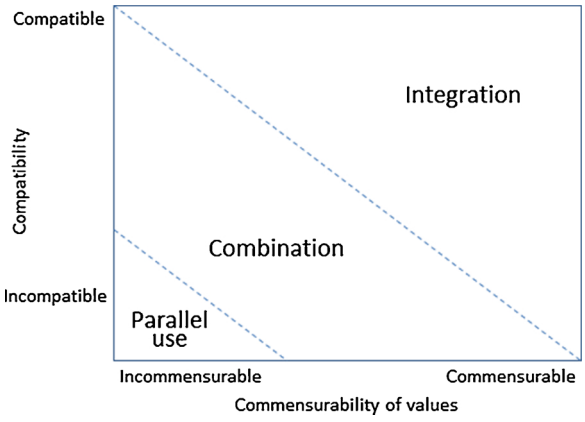

Fig. 9. General integration framework. Commensurability refers to whether value dimensions and approaches are logically commensurable, and compatibility refers to whether valuation methods are technically compatible. Source: Kronenberg and Andersson (2016), courtesy of GREEN SURGE.

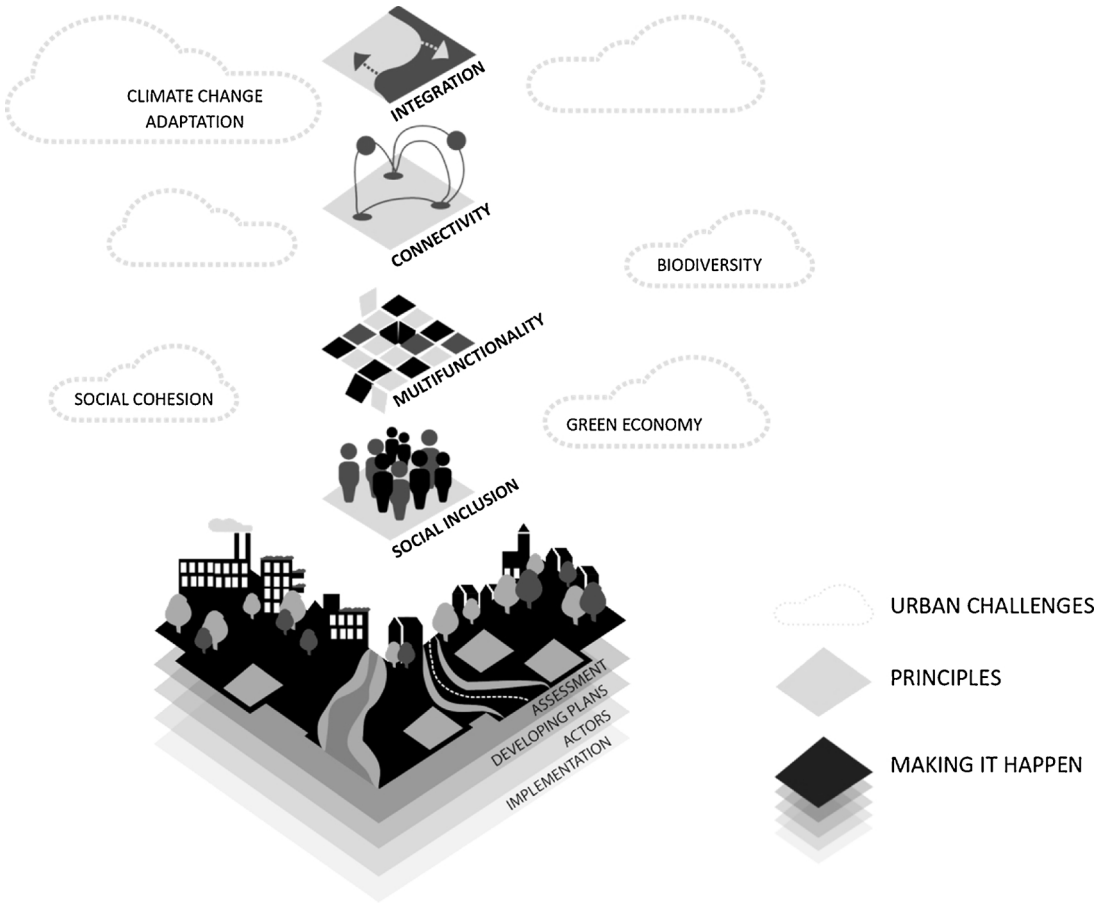

Fig. 10. Conceptual scheme illustrating the understanding of UGI planning developed by the GREEN SURGE project. The four planning principles help cities to tackle challenges such as climate change adaptation or biodiversity protection. On the ground plans need to be based on sound assessments and developed in cooperation with different actors and implementation mechanisms.
Courtesy of GREEN SURGE.

Municipalities mobilising social capital	Strategic planning instruments to invite grassroots and individual citizens to participate in place making or place-keeping
Green hubs	Experimental, creative coalitions connecting various networks and knowledges to develop community based solutions.
Grassroots initiatives	Relatively small scale initiatives located on public land, started and maintained quite autonomously by local residents.
Co-governance	Partnerships between municipality and citizens or grassroots with power being between across actors.
Organization initiated grassroots	Social enterprises or NGO's mobilising community action, in focus and power located between co-governance and grassroots initiatives.
Green barters	Maintenance or development obligation for businesses in exchange for a formalised right to use the values of space for business profits.

Fig. 11. During the GREEN SURGE project, six types of governance arrangements were identified, ranging from government-led participation to co-governance and self-governance.
Source: Buijs et al. (2016a); courtesy of GREEN SURGE.

room for this variation remain a main challenge. For example, strategic top-down planning does not always involve diverse and difficult-to-engage urban communities in decision-making in an equitable manner (Davies et al., 2015); self-governance initiatives can be strongly dependent on favorable external factors such as access to land or availability of resources (Mattijssen et al., 2017), or might only manage small sites disconnected from the larger mosaic of green infrastructure (Buijs et al., 2016a). Moreover, values and objectives of different parties in co-governance arrangements do not always align and an imbalance in power relations can have impacts on the form and function of green spaces (Buijs et al., 2016a).

Our studies have reinforced the importance of coalitions, and their 'contracts'; planning and governance of UGI is not a matter of using an either-or approach. The challenge is to combine the strengths of different actors in order to match the needs of a specific situation. GREEN SURGE advanced the idea of *mosaic governance*, conceptualized as a context-sensitive, flexible planning approach that integrates the spatial (ecological) and social dimension of UGI, aiming at a flexible mix of government-led strategic planning and local, bottom-up active citizenship initiatives (Buijs et al., 2016b, 2018, this issue).

The BCD concept, on the other hand, gave a new, transdisciplinary perspective on the diversity of human-nature relationships. The concept was originally developed to describe resource use and management by indigenous people (Cocks et al., 2016). In urban contexts, the approach may be used to better understand and evaluate people's diverse interactions with UGI as well as enhance stewardship and thus move beyond policy-making narrowly focusing on biodiversity alone. It also provides support for a context-sensitive and site-specific approach to planning and management (see Elands et al., 2018; Luz et al., 2018).

In a similar vein, the framework for integrated valuation of UGI is a step towards a more informed discussion of what a livable city is and who the beneficiaries of UGI might be. The framework developed in GREEN SURGE, with its different levels of integration, offers a better way to understand and discuss different value dimensions, i.e. under what circumstances they can be directly connected and when fundamental differences require more complex translation processes. Conceptually, the framework offers some guidance for how to approach complex social-ecological systems (Andersson et al., 2014) through multi-methods and transdisciplinary approaches.

7.2. Contributions to UGI evidence base

UGI decision-making critically hinges on being grounded in an evidence base that provides the necessary knowledge on urban green and blue spaces, their status and dynamics, the functional relationships with ES and how all of this relates to human perception, valuation and governance. This paper only presented selected findings on the contribution of GREEN SURGE to the evidence base, which we consider as main contributions.

The study of UGI patterns and dynamics at the European-level showed that the challenges for UGI differ widely across Europe, which adds to previous research on the role of local context and urban form (Fuller and Gaston, 2009; Kabisch and Haase, 2012).

GREEN SURGE gave new insights into, for example, the large variation in terms of green space provision and composition of different UGI types, including information on opportunities to access nearby green space. Such insights are crucial for informing policies at national and European levels to achieve a more balanced territorial development and to monitor their success.

The UGI typology was a foundational element in these studies and was further applied to review the links between UGI types and ecosystem services. More efforts should be made to establish enhanced systems for the accurate and continuous assessment of urban green space and their ecosystem services at European, national and city levels. Presently, many UGI types identified in the GREEN SURGE typology are neither represented in the Urban Atlas dataset nor in other pan-European land cover classifications such as CORINE land cover or Open Street Map (Feltynowski et al., 2018)

The work in GREEN SURGE also added to the growing evidence base on the values of urban nature. For instance, the spatially explicit assessments of cultural ES via PPGIS in Berlin, Lisbon and Łódź (Rall et al., 2017; Luz et al., 2018; Czembrowski et al., 2016a), and social media volunteered geographic information (VGI) in Copenhagen (Guerrero et al., 2016) gave valuable insights into the use patterns and perceptions as well as cultural values respondents associated with particular green spaces. Particularly the study on the use of different green space types and the perception of biodiversity in the five ULLs has led to a better understanding of the similarities and differences across European cities (Fischer et al., 2018c).

Results reinforce that biodiverse urban green spaces contribute to livable cities, support a wealth of social activities and interactions and thus provide strong social arguments for integrating biodiverse green spaces in urban development. There is, however, an urgent need for recognizing cultural diversity and its dynamics in lived, materialized and stewardship BCD in urban green space policies and management practices.

The local diversity of human-nature relationships, identified by the BCD studies, ultimately highlights why local contexts are always relevant. Urban green does not provide a universal solution in itself: this depends on the specific social and environmental networks in which these spaces are embedded. Our work emphasizes that the availability of good quality data can greatly contribute to the quality of UGI decision-making along with integrated valuation taking into account context sensitivity – especially when complemented with a qualitatively rich understanding of local contexts and an implementation process sensitive to history and current condition. The broad GREEN SURGE approach supports an understanding of solutions as fluid and changeable. Instead of general answers, GREEN SURGE offers methods and approaches for translating concepts and examples across cases. To this end, a GREEN SURGE handbook was prepared, including briefs, factsheets and reports for policy-makers as well as comprehensive guidance for UGI valuation, planning and governance (Kronenberg et al., 2017; Hansen et al., 2017a,b; Ambrose-Oji et al., 2017).

7.3. Developing the science – practice interface

The LA process evaluation showed that the GREEN SURGE project influenced UGI planning, governance and implementation to various extents in the five ULL cities. Participants in these processes were inspired to consider new planning concepts and increased their familiarity with and confidence in innovative ways of planning and governing UGI. The LAs also strengthened collaboration through the regularly scheduled meetings. Researchers benefited from collaborating with practitioners, as evidenced by improved access to local knowledge and new research ideas from working partnerships. To take the "double helix" approach further, GREEN SURGE experiences point to the importance of discussing process expectations early on, involving people who are open to co-creation of knowledge, searching for a common language, preparing a schedule with regular meetings, creating a group identity, identifying common objectives that add value to all and engaging in monitoring (Reil et al., 2017).

7.4. Reflections

Reconciling humans and nature is key to UGI development, for three reasons: (i) in times of biodiversity crisis, cities should also contribute to solutions by supporting biodiversity across all types of urban ecosystems (Aronson et al., 2017; Kowarik and von der Lippe, 2018); (ii) while contacts of people with the natural environment in general seem to decrease (Soga and Gaston, 2016), opportunities for urban people to interact with nature are especially under pressure given the compact cities agenda (Lin and Fuller, 2013); and (iii) stewardship of nature and

ecological processes is a co-responsibility of local authorities, NGOs, businesses as well as citizens living in urban areas (Andersson et al., 2017a).

Therefore, there is a need for gaining more in-depth information on different cultural framings and how different groups perceive different UGI constellations. Cultural diversification and the impact of influxes of migrants into cities will increase challenges related to equitable realisation of multiple benefits and aspirations. Moreover, due to the emergence of new urban values regarding biodiversity and a growing disconnection between citizens and nature, shifts in values and meanings regarding UGI and biodiversity may occur as well. A biocultural diversity approach will help account for, and hopefully engage with, these dynamics.

UGI governing systems should aim for involving a large diversity of urban actors and coalitions while providing multifunctional, connected and accessible green spaces. This, together with a changing landscape of ownership and management responsibilities, requires a combination of incremental and flexible governance approaches with strategic planning cutting across different sectors and spatial scales. GREEN SURGE has also shown that the green economy and urban governance are inextricably interconnected, and that there are many different ways in which commercial interests can be included in UGI planning. The green economy has gained traction already with today's financial and regulatory systems, but many of the promising seeds of novel practices need a shift in overall governance to really take off (cf. Elmqvist et al., 2018). In this context, valuation and an informed discussion about values are important for raising questions around inequity and unfair distribution of opportunities to benefit from UGI (Haase et al., 2016). Balancing economic interests and the interests of different city residents is a governance challenge that must be met.

Inclusive forms of green space governance with broad participation of grassroots and business interests can be strengthened and better linked with strategic planning through situation sensitive support from local governments. In times of rapid change, flexible governance arrangements not only have implications for current livability of cities but may also offer a way to build in insurance value and resilience into our cities and our daily lives (Andersson et al., 2017b). However, it is important to be aware that objectives of authorities and non-state actors do not always align and that collaboration is not always successful.

Finally, follow-up studies are necessary to explore if GREEN SURGE outputs and the outcomes of site and policy experiments in the ULLs and LAs will continue to be applied and act as an ongoing source of knowledge and inspiration in the decision-making processes of the participating local authorities. For researchers it offers an opportunity to reflect on the questions they ask and why, and what the wider implications of different studies might be.

Reflecting on this four-year research journey, we have come to a much better understanding of the realities of UGI planning and governance, and the inextricable links with transdisciplinarity, integrated valuation and the creation and conservation of biocultural diversity. What stands out is the multiplicity of green space types, actor constellations, nature values and socio-physical contexts that together determine the functioning and effectiveness of UGI. Introducing new methods and frameworks, we have laid the groundwork for an improved understanding and mapping of this complex reality. With the case for UGI only getting stronger with ongoing urbanization and climate change, future collaborative research is needed in these areas in order to build upon these foundations for more equitable, livable and healthy urban futures.

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