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Resilience of and through urban ecosystem services

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ABSTRACT

Cities and urban areas are critical components of global sustainability as loci of sustainability progress and drivers of global transformation, especially in terms of energy efficiency, climate change adaptation, and social innovation. However, urban ecosystems have not been incorporated adequately into urban governance and planning for resilience despite mounting evidence that urban resident health and wellbeing is closely tied to the quality, quantity, and diversity of urban ecosystem services. We suggest that urban ecosystem services provide key links for bridging planning, management and governance practices seeking transitions to more sustainable cities, and serve an important role in building resilience in urban systems. Emerging city goals for resilience should explicitly incorporate the value of urban ES in city planning and governance. We argue that cities need to prioritize safeguarding of a resilient supply of ecosystem services to ensure livable, sustainable cities, especially given the dynamic nature of urban systems continually responding to global environmental change. Building urban resilience *of* and *through* ecosystem services, both in research and in practice, will require dealing with the dynamic nature of urban social–ecological systems and incorporating multiple ways of knowing into governance approaches to resilience including from scientists, practitioners, designers and planners.

1. Introduction

Cities and urban areas are critical to global sustainability since they are the locus of much of the sustainability progress and are drivers of change, especially in terms of energy efficiency (Slavin, 2011), climate change adaptation (Rosenzweig and Solecki, 2010), and social innovation (Bettencourt et al., 2007). Many cities have sustainability plans, but have not specifically addressed urban resilience, or if they have, often conflate or use sustainability and resilience interchangeably (Redman, 2014). Lack of resilience to social, ecological, and economic disturbances can shift urban system trajectories away from sustainability. Recently however, improving specific resilience (Carpenter et al., 2001), especially in sensitive areas of urban systems experiencing climate change, urbanization, and development pressures, is of increasing concern with cities beginning to develop specific plans and resilience targets (Solecki et al., 2011; PlaNYC, 2013), especially for reducing disaster risks and vulnerabilities to climate change (Pickett et al., 2004; Elmqvist et al., 2014). For example, the Mayor's office of New York City responded to the widespread damage from Hurricane Sandy (2012) by creating a high-level "Special Initiative for Rebuilding and Resiliency" (New York City Special Initiative for Rebuilding and Resiliency (NYCSIRR): New York City Office of the Mayor, 2013). Many other motivated mayors, urban planners, and designers are increasingly considering how new development plans and projects can contribute to and foster resilience to climate change and it's myriad effects (Rosenzweig et al., 2010). In coastal cities for example, mitigating and planning for disasters and effects of sea level rise including coastal flooding and storm surge is a growing mandate (Rosenzweig et al., 2011)

Resilient supply of non-disaster related ecosystem services (ES) provided within urban areas has received little attention. Though some cities are beginning to consider how ecosystems in cities can help mitigate climate change effects or create spaces that increase existing adaptive capacity for post-effect recovery, in most global cities services provided by urban ecosystems remain poorly connected to urban planning, design, and management for resilience (Scarlett and Boyd, 2013). We argue that cities will need to plan and manage urban ecosystems for enduring supply of services in dynamic urban systems affected by global environmental change. Therefore, we propose that ES and resilience are related in two ways: First, resilience can be fostered by incorporating the concept of ES in urban planning, design and management of urban social–ecological systems. Second, cities need to safeguard resilient supply of ES in the long-term to ensure urban human well-being (Fig. 1). For these reasons we suggest that urban ES provide a key

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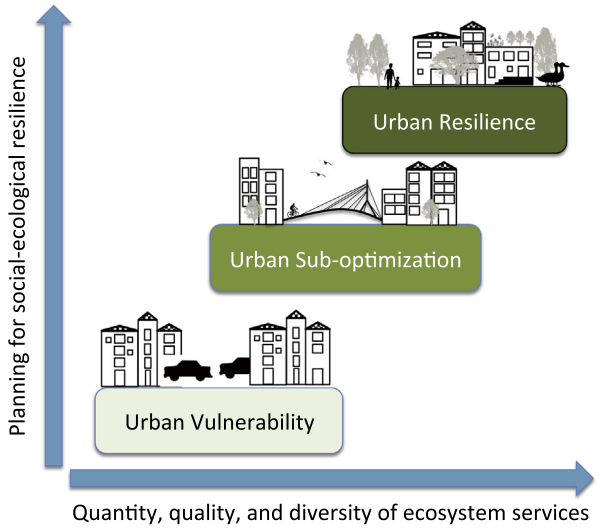

Fig. 1. Urban resilience can be fostered by incorporating urban ES in planning, design and management of urban social–ecological systems. A social–ecological approach for cities is critical to safeguard a resilient supply of ES in the long-term to ensure urban human well-being (Schewenius et al., 2014; Elmqvist et al., 2014). However, safeguarding urban ES requires recognizing and incorporating the multiple values of ES in planning and governance. As urban planning and governance for social–ecological resilience increases, together with conservation of and management for increased quality, quantity, and diversity of urban ES, resilience at multiple scales can be improved.

entry point (Andersson et al., this issue) for planning, management and governance practices seeking increased resilience and transitions towards urban sustainability (Frantzeskaki and Tilie, 2014).

2. Sustainability, resilience, and urban ecosystem services

Though governance practices and planning approaches for urban sustainability must consider the large urban footprint to improve sustainability, here we focus on the internal footprint of cities and specifically the sustainable production of ES in the city. Urban ES provide important ways for improving sustainability by locally providing services to urban residents, decreasing reliance on externally produced services, and thus decreasing the global footprint of cities. Such urban ES include local food and water production (Gómez-Baggethun et al., 2013), and utilizing green infrastructure in place of environmentally and economically costly grey infrastructure for reducing impacts of stormwater on urban drainage systems therefore lowering the risk of surface water flooding (Kaye et al., 2006; Pataki et al., 2011; Alamarie et al., 2010; McPhearson et al., 2013a). There are also many ES critical to human health and wellbeing that cannot be imported and must be supplied locally within urban ecosystems (McPhearson et al., 2013b; Andersson et al., this issue), for example utilizing urban parks, green walls and roofs, and street trees to offset urban heat islands and thereby reducing energy use for cooling (Gill et al., 2007; Pataki et al., 2011), or the mental and physical health benefits provided by urban green infrastructure (Gómez-Baggethun et al., 2013).

Overall, urban ecosystems provide a large roster of critical services affecting human health and wellbeing in cities (Elmqvist et al., 2013; Gómez-Baggethun et al., 2013; McPhearson et al., 2014). However, while research to predict and understand urban climate change is expanding rapidly (Rosenzweig et al., 2011), we still know little about how climate change will affect urban biodiversity and the ecological structure, functions, and services that affect human livelihoods in cities (Solecki and Marcotullio, 2013). Urban ES may be vulnerable to change, whether by land use change and development or from other sources of change including climate change, extreme events, or political and economic change (Seto et al., 2012). Further research is needed to understand how climate interacts with and drives changes in urban ecosystems, and therefore how these changes will affect the supply of ES. We need to understand the resilience *of* urban ES, and how it is linked to global and local social–ecological changes as well as how changes in urban ES feedback to impact resilience within urban systems at multiple scales.

Resilience is generally considered in the context of response to sudden impacts like natural disasters (Alberti et al., 2003; Pickett et al., 2004). However, the resilience concept is not limited to recovery from a single disturbance. Resilience is a multidisciplinary concept that encompasses persistence, recovery, and the adaptive and transformative capacities of social–ecological systems and subsystems (Holling, 2001; Walker et al., 2004; Biggs et al., 2012). Improving resilience at both small and large system scales depends on answering the question of resilience "of what, to what" (Carpenter et al., 2001), and, perhaps especially in urban areas, resilience "for whom" (Pickett et al., 2011). Including urban ES in resilience planning and management can help to address these questions. Below we discuss three overlapping ways to help to connect urban ES to resilience in urban systems.

2.1. Insurance and option values

The value of resilience through urban ecosystems has so far not been included in urban ecosystem services valuation and assessment. We suggest insurance and option values as two key aspects for connecting urban ES to resilience in valuation studies, and that accounting for both insurance value and option value of ecosystems in urban resilience targets will both increase the likelihood that ecosystems are managed for resilient supply of services, and that resilience targets will be met. While multiple definitions exist, we propose that insurance value reflects "the maintenance of ecosystem service benefits despite variability, disturbance and management uncertainty". Therefore, the insurance value of an ecosystem is closely related to its resilience, self-organizing capacity, and to what extent it may continue to provide flows of ecosystem service benefits over a range of variable environmental conditions. Option value instead focuses on the maintenance of alternative uses or solutions and the reversibility of decisions (Pascual et al., 2010). For example, multifunctional green infrastructure allows for different uses and for different ecosystem service benefits that can be utilized at different times. A well-known case is how urban parks were used for food production instead of recreation during the two World Wars (Barthel et al., 2013). Less dramatic changes in how ecosystems are used and valued include shifts from regulating services to recreational services (e.g. wetlands in the Kristianstad Vattenrike Biosphere Reserve, Sweden) (Olsson and Galaz, 2009).

2.2. Resilience through urban ecosystem services

High population density, high connectivity and dependence on infrastructure can make urban populations vulnerable to disturbances, such as flooding, heat waves, disease outbreaks, land slides, and storms (Peters et al., 2004). Ecosystems within and around cities can provide insurance by helping to buffer against many of these disturbances. Resilience to specific events, whether climate mediated or not, may arise through ES where benefits occur during or shortly after the event. This specified resilience could be understood and addressed through urban planning and management targeting green infrastructure and associated ES. For example, mangroves and

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