Mapping ecosystem services on brownfields in Leipzig, Germany

Catharina Pueffel [a], Dagmar Haase [a,b], Joerg A. Priess [b,*]

[a] Humboldt University, Berlin, Germany
[b] Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

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ABSTRACT

Urban green brownfields are a particular type of urban green space and contribute to the quality of life by providing a variety of ecosystem services (ES). In this study, we mapped the use of ES and perception of disservices (EDS) on brownfields in the city of Leipzig using the smartphone application MapNat. We assessed the personal valuation and motives of users in relation to site and vicinity characteristics. Results suggest that brownfields play a particular role in the set of urban green spaces, providing characteristic ES such as opportunities to recreate, relax and retreat, partly differing from or complementing ES in formal urban green spaces. We identified spatial use patterns depending on local characteristics and personal preferences. For example, less accessible sites were relatively high valued and often used for dog-walking. Vice versa, better accessible sites were rather visited for informal stays and 'hang-outs'. The patterns of use identified in this study may be of interest for urban management and planning of public green spaces, especially if no immediate follow up use or conversion of brownfields is planned.

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1. Introduction

In an increasingly urbanized society in which more than half of the world's population and around 75% of the European population lives in cities, the impact of urban ecosystems on human well-being and quality of life attracts more and more attention in research and policy in the context of sustainable urban development (Bertram and Rehdanz, 2015; Dye, 2008). This has significant implications for human environmental relations due to the fact that high population density and resource use in cities put great pressure on urban environments, while these simultaneously provide various benefits – referred to as ecosystem services (ES) – in close proximity of peoples' places of residence (Gómez-Baggethun and Barton, 2013; Haase et al., 2014). Some functions of (urban) ecosystems may also have negative or even harmful effects on human well-being and are often referred to as ecosystem disservices (EDS) (Lyytimäki and Sipilä, 2009).

One particular type of urban green space can be provided by brownfields – also known as 'previously used land', 'urban wastelands', 'derelict land' or 'fallow land' (Atkinson et al., 2014; Mathey et al., 2015). Basically, these terms refer to parcels of land that formerly have been developed and used by industry, infrastructure, buildings, agriculture or other anthropogenic activities, and are now abandoned (CABERNET, 2006; Siebielec et al., 2012).

Brownfields that are significantly covered by tree, shrub and grass vegetation contribute to the variety of urban green space and host particular ecosystems that provide habitat services, microclimate regulation and especially cultural ecosystem services (CES) such as recreational services (Mathey et al., 2015).

Although well-structured frameworks for the assessment of ES have proven helpful assessing the value of nature, the actual use and appreciation of services by the general public often differ from the potential supply (Larson et al., 2016). This knowledge is important, however, in order to analyse the actual valuation of services and the appreciation of urban green spaces (Rall and Haase, 2011; Rall et al., 2017). Which is why this study assesses both actual use and public perception of urban ES on brownfields as a special type of urban green space.

The city of Leipzig, Germany is an especially suitable and interesting study site for mapping ES on urban brownfields because many of them still exist from a period of de-industrialization and urban shrinkage after the German reunification in 1990 that has shaped the city until recently. According to the Agency of Green Space and Water (in German: Amt für Stadtgrün und Gewässer), 545 parcels are under construction, 3407 are classified as derelict land, and 4914 as revitalized, which means that they were converted from lying fallow into formally used land – irrespective of the type of use, which could hence be green space as well as construction site (Stadt Leipzig, 2016a). For half a decade the trend of city-wide urban shrinkage in line with increasing numbers of brownfields has changed and population numbers in Leipzig are

* Corresponding author.
  E-mail address: joerg.priess@ufz.de (J.A. Priess).

increasing again. Thus, previously neglected urban brownfields are increasingly considered highly profitable investments for construction projects. At the same time they offer great potential for greening the city (De Sousa, 2003) and providing urban ES. This predicament of being both valuable but threatened demonstrates that more knowledge is needed on the use and appreciation of green urban brownfields.

The objective of this study is to analyse how vegetated urban brownfields are used as a type of urban green space and to elaborate their role in providing ES. Special emphasis is put on cultural ES, and especially recreational services, since these are more widely acknowledged than other environmental benefits (Larson et al., 2016). As a systematic procedure to address this topic, the approach is to empirically assess which ES are used on brownfields in Leipzig using the smartphone application 'MapNat', a new version of the ESM-App (Priess et al., 2014), and to understand if and why certain patterns of human use exist across selected brownfields that differ in terms of certain factors. These factors include site characteristics and properties of their direct surroundings, but also priorities of users regarding frequency and valuation of ES and their motivations to visit brownfield sites.

The analysis follows one guiding hypothesis:

The explored brownfield sites have distinct characteristics that determine particular patterns of using ES and perceiving EDS.

Four research questions are based on the hypothesis:

1. Which types of ES are used on selected brownfields in the inner-city area of Leipzig?
2. How do users value the services in terms of frequency of use and level of importance?
3. How can different types of use be explained based on site characteristics, the surrounding area, individual user preferences and temporal aspects such as time of day?
4. Which role do brownfields play for the entirety of urban green space in a city? Do they provide unique characteristics that make them a particular type of urban green?

Five main sections structure this paper. Following this introduction, Section 2 defines urban ES and EDS that are provided by urban ecosystems and summarizes what is known about the potentials of green urban brownfields to provide the latter. Section 3 explains the methodology used to map and assess the use of ES on selected brownfields in Leipzig. Section 4 presents which ES have been used on brownfields and which patterns of use could be observed. These findings are discussed and interpreted in Section 5. Finally, Section 6 concludes major findings and identifies aspects to be emphasized in future research.

2. Concepts and definitions

A wide range of societal and environmental benefits of urban green spaces and green infrastructure have been acknowledged in the scientific literature and policy documents (Atkinson et al., 2014; BMUB, 2015). To account for the complexity of these contributions, their synergies and trade-offs, it is important to use common concepts and definitions. One way to structure these contributions is the framework of ES (Haines-Young and Potschin, 2010), which has gained increasing international attention in the past decades (Schröter et al., 2014). In this work, the "Common International Classification of ES" (CICES) serves as a guiding classification, as it also served as a basis for the ES categories used in the MapNat application (see CICES.eu). Other than comparable classifications, such as "The Economics of Ecosystems

and Biodiversity" (TEEB), this hierarchical approach defines only three instead of four main sections of ES, namely provisioning, regulating and CES. Table 1 provides an overview of the respective classes and subgroups.

In order to assess the goods and benefits of different habitats, these general classifications have to be transferred to particular types of ecosystems (Andersson et al., 2015). In this regard, urban ES are the ones provided by urban ecosystems (Gómez-Baggethun and Barton, 2013), which can briefly be defined as "all natural green and blue areas in the city" (Bolund and Hunhammar, 1999, p. 294). They are particularly relevant to urban dwellers because they contribute directly to health, security and quality of life since they are not transferred over long distances (e.g. ecosystem flows from rural areas to the city) but used at the place where they are produced (Burkhard et al., 2014). While numerous provisioning and regulating services have been identified for urban areas, e.g. food supply, urban air temperature regulation, noise reduction, air purification, or climate regulation, the ones that are most perceived and acknowledged by the general public are said to be CES because their recognition requires less expert knowledge of ecological processes (Andersson et al., 2015). Instead, they "are directly experienced and intuitively appreciated" (Daniel et al., 2012, p. 8812).

In this study, the focus specifically lies on green urban brownfields, being primarily covered by vegetation with the potential to provide numerous environmental benefits, such as climate change mitigation and adaptation (micro-climate regulation), habitat services and biodiversity (habitat for many different and often rare plant and animal species), as well as cultural and recreational services for local residents (Mathey et al., 2015). However, previous studies also mentioned negative perceptions of urban brownfields due to certain site-specific characteristics, such as unattended sites with spontaneous vegetation and ecological succession and partly misused as waste deposits. On the other hand, ecological succession was also found to be valued by the local population (Mathey et al., 2015). This phenomenon brings up the discussion about EDS. Here, several authors (e.g. Gómez-Baggethun et al., 2013; von Döhren and Haase, 2015) refer to a definition of EDS by Lyytimäki and Sipilä (2009, p. 311) "as functions of ecosystems that are perceived as negative for human well-being". Since EDS are perceived in a socio-ecological system it is often difficult to distinguish between EDS that are induced exclusively by the ecosystem and the ones that result from human influence. It is important to note that, according to the definition here, "ecosystem disservice can originate from ecosystem functions regardless of how much they are or are not influenced by human activities" (ibid., p. 311). In contrast to conclusions by other scholars (e.g. Shackleton et al., 2016), this makes toxic plants just as much an EDS as the sea level rise due to climate change or trash in urban parks jetted by careless visitors (Lyytimäki and Sipilä, 2009). However, the perception and level of disturbance vary with socio-cultural aspects "such as gender, age, income, cultural background, or knowledge level" (Lyytimäki, 2015, p. 1) and with the way people perceive a disturbance, which makes it quite challenging to assess EDS objectively and quantify them in a singular way (Lyytimäki et al., 2008).

In order to examine which role these ES and EDS actually play for the people living in cities, one has to consider that the valuation of services is highly complex and comprises different value domains (Jacobs et al., 2016). The socio-cultural valuation is especially far from neutral or objective, but rather culturally constructed and normative (Haines-Young and Potschin, 2010; Swyngedouw, 2010). In this study, the valuation of ES was addressed by users in terms of importance and use frequency of a specific ES.