PLANT*enary* URBANISM
about migrating species and human happiness

Background

Together with the human population, urban areas are growing worldwide – in dimensions barely conceivable: According to Vaclav Smil (2013), China alone has used more cement between 2011 and 2013 than the US in the entire 20th century. In Germany, each day about 73 hectares of unsealed surface are transformed into mostly impervious, built-up areas, which is a lot more than the 2020 aim of 30 hectares of land consumption (BMUB 2014). This surface sealing destroys or fragments habitats of diverse animal and plant species, and even entire ecosystems. Thus, urbanization causes a general decline in biodiversity, for example, of rare and endemic species (McKinney 2002). Besides climate change, the loss of biodiversity is understood to be the biggest ecological catastrophe of the present: Even though quantitative estimations must be treated with care, 20 species may become extinct each day (Streit 2010).
The urban densification poses risks to humans as well. That is, urban dwellers face diverse environmental burdens, resulting from industrial production, heavy traffic, and a high building density. These burdens may not only challenge physical health, but also psychological well-being by causing stress (e.g. Evans 2001). Stress-related diseases have become more common in recent decades and accumulate in cities (Galea et al. 2005, WHO 2009).
However, research has lately shown how these risks of urbanization can be faced: Stays in, or views of vegetated urban areas can reduce stress and thus, improve city residents' health (Velarde et al. 2007). A high diversity in vegetation may be especially beneficial for human well-being (e.g. Fuller et al. 2007). Although many native species migrate or become extinct within cities (e.g. species adapted to mesic conditions, Knapp et al. 2010), other native (e.g. dry grassland species on former demolition sites, Fischer et al. 2013a) or non-native species (e.g. mediterranean species that rely on higher temperatures) may profit from the specific urban conditions an contribute to urban biodiversity (Kowarik 2011). Thus, urban biodiversity provides potentials for city residents' experiences that shall not be underestimated (Miller 2005).

Summary and hypothesis

The worldwide urbanization is related to a decline in biodiversity and an increase in stress-related diseases. However, cities can provide niches for diverse species, and for restorative environments for the human population. Targeted measures may promote biodiversity and human health at the same time.

Information processing

In order to visualize the extent of built-up and sealed sites in urban areas, and the existing ecological potentials on different land uses, we chose Berlin as a model city: Berlin is often perceived as an above-average green city. Due to its specific history – resulting in gaps between buildings caused by the destructions of WWII and the undeveloped areas around the Berlin wall after German reunification – Berlin has multiple different green spaces and wastelands. Nevertheless, the present degree of sealing of about 35% is determined to be relatively high (SenStadt 2015a). In 2014, Seitz et al. described a total of 2445 taxa for Berlin, and more than half of these are established – which makes Berlin a very species-rich city.

In order to study and visualize our hypothesis, we initially investigated the percentages of different land uses in the urban area of Berlin (segments in *drawing I*). Consecutively, we researched scientific studies that provided insights into the following ecological functions of these land uses: Effects on microclimate, sealing degree/impervious layers and soil depth, relations with biodiversity and with the „happiness", or well-being, of city dwellers. The latter summarizes studies on human physical and mental health, on residential and life satisfaction, and on cognitive functioning. The ecological dynamics of species migration shown in *drawing II* summarizes examples from international studies and sheds light on different processes as well as temporal and spatial backgrounds of species migration. *Drawing III* illustrates potential implications for several land uses that promote biodiversity and/or human happiness.

Besides the above-mentioned references, data and information were derived from the Environmental Atlas of the Senate Department for Urban Development Berlin (SenStadt 2015b), from urban-ecological (e.g. Banaszak-Cibicka & Żmihorski 2012, Kattwinkel et al. 2011, Lehmann et al. 2014, Maurer et al. 2000, Nielsen et al. 2014, Politi Bertoncini et al. 2012, Sukopp & Wittig 1998, Thompson et al. 2003, von der Lippe & Kowarik 2008) and environmental psychology (e.g. Hofmann et al. 2012, Nassauer 1995, van Dillen et al. 2011, Ward Thompson et al. 2010, Weber et al. 2014) literature including own research (Fischer et al. 2013 a & b, Honold et al. 2015).

Results & implications

Many urban land uses bear the potential to conserve and promote biodiversity *and* human well-being. The comparison of findings from environmental psychology and vegetation ecology suggests that measurements and concepts for promoting one of them may also foster the other:
(a) Dense built-up and traffic areas increase the urban climate significantly (urban heat island effect) and bear the risk of flooding due to low permeability of the soil surface. Moreover, high building density alone may cause stress by feelings of crowding and provides little habitat for flora and fauna. Still, traffic areas or their edges such as road verges may offer habitat for specialized species (e.g. thrift seapink, *Armeria maritima*), and roadside vegetation can improve human residents' well-being. Vegetated facades and roofs can function similarly and can also provide habitat for insects and birds.
(b) Larger vegetated areas and urban parks with a high portion of trees and shrubbery can cool the urban climate and absorb high amounts of precipitation due to their low sealing degree. Most evidence on the restoration potential for stressed urban residents is available for traditional parks. The same applies to the value of parks for urban biodiversity: For example, the potential of very old trees as habitat for rare species such as the great capricorn beetle (*Cerambyx cerdo*) was determined. Some meadows that are mown only once or twice a year can even possess a legal conservation status due to their special species composition. Thus, meadows may be preferred over lawns if aesthetic considerations would not suggest other management strategies. Patches with old-growth and dying trees as well as dead wood should be left in wooded areas of parks.
(c) Such management strategies that support biodiversity in urban parks may also applied to old cemeteries. To date, these, however, have been understudied.
(d) Allotment gardens are estimated richer in species if a mosaic of high- and low-maintenance areas exists. Moreover, views of or gardening in allotment gardens can be beneficial to health and foster social networks.
(e) Wastelands bring about better effects for urban climate in later successional stages that entail higher amounts of vegetation but highest species numbers were found on wastelands with successional stages of up to 15 years. Therefore, for biodiversity conservation at least parts of the vegetation on wastelands should be disturbed regularly. This way, successional stages also include open and pioneer areas. This can be initiated by disturbing the soil surface with baggers, by uses such as motocross races, or by cattle grazing. With regard to human happiness, "cues of care" such as designed paths, park benches, or trash bins should be added.
(f) Urban forests have the strongest cooling effects, can absorb high amounts of precipitation and have a high restoration potential if they are rather tended and open than with a dense understorey. As described before for historic parks, old and dying trees should be conserved and

dead wood should be left in wooded areas from an ecological perspective. Different age classes and a mix of different woody species promote the establishment of further species groups.

In general, the dense mosaic of different land uses in urban areas is an important factor for urban biodiversity. In some typical urban land uses (e.g. built-up areas), a lot can be achieved by simple measures (e.g. the conservation of habitat for bats by keeping open small cracks in roof beams). In the light of the fact that urban dwellers have decreasing chances of experiencing biodiversity ("extinction of experience", Miller 2005), measurements that promote biodiversity may not only be beneficial to plant and animal species, but also to human happiness.

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