Plant sciences for the Anthropocene: What can we learn from research in urban areas?

Editorial

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EDITORIAL

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1 | INTRODUCTION

There is no doubt, we live on a planet dominated by one keystone species—*Homo sapiens*. The biomass of humans and their livestock make up c. 95% of all mammals and birds on the planet (Bar-On, Phillips, & Milo, 2018). Almost the whole Earth, with the exception of unproductive areas such as deserts and high latitudes, is intensively used by humans resulting in novel and human-dominated biomes—so-called anthromes (Ellis, 2015). Evidently, the major conceptual challenge for ecology in the 21th century is to understand a natural world in which most ecological processes and patterns are shaped by humans (Ellis, 2015; Kueffer, 2017). Framing the role of humans in nature as an external factor that disturbs from the outside the self-organization of ecosystems has become anachronistic (Krasny & Tidball, 2015; Kueffer, 2015). The Anthropocene is not the culmination of modernity resulting in the ultimate emancipation of humans from nature. Rather it is the end of modernity—the moment when we realize that we have to find a new place in the web of life that, however, is now fundamentally different from pre-modern times.

Although urban areas cover only a few percent of the planet's surface, more than half of the human population is urban, and the vast majority of resources and energy (and with this indirectly land) is used by urban populations (IRP, 2018; WBGU, 2016). Urban areas are thus paradigmatic places for an ecology of the Anthropocene and for a transformation of society toward a sustainable future. They are pivotal nodes of the global ecosystem, and it is in cities where the majority of humans and influential decision-makers experience nature and other species. Cities can be rich in biodiversity (e.g., Ossola & Niemelä, 2017), and they are hotspots of rapid evolution and the formation of new biodiversity (Schilthuizen, 2019). Not surprisingly, urban ecology is a fast-growing research field (e.g., Alberti, 2008; Forman, 2014; Gaston, 2010; Hall & Balogh, 2019; Krasny & Tidball, 2015; Marzluff et al., 2008; Ossola & Niemelä, 2017; Pickett, Cadenasso, & McGrath, 2013), and nature-based solutions increasingly influence the design of materials, buildings, infrastructures, and cities (e.g., Myers, 2018; Roggema, 2020; WBGU, 2016).

Urban ecology transgresses biology and integrates concepts from systems science, geosciences, social and cultural sciences, and urban planning and design among others. However, there is surprisingly little feedback of such interdisciplinary urban research on the discipline of ecology. Basic ecology largely still aims to investigate the generality of ecological laws in non-anthropogenic nature thereby neglecting interdependences of ecosystems with technological, social, and cultural systems. Such a resistance to conceptual innovations from 'applied' research that already addresses the emerging phenomena of the Anthropocene is widespread in ecology, and it can, for instance, also be observed at the intersections of ecology with invasion science (Kueffer, 2017; Vaz et al., 2017). While geographers, cultural and social scientists working on the ecology of globalized floras and faunas integrate insights from ecology and evolutionary biology, invasion biology still largely ignores the social and cultural factors that drive and explain invasion dynamics (Kueffer, 2017; Vaz et al., 2017).

This Virtual Issue featuring articles published in *Plants*, *People*, *Planet* highlights the great diversity of botanical research in urban settings. In three sections, I will explore how the compiled research contributes to three questions that arguably must be at the core of ecology in the Anthropocene:

- *Ecological Novelty*: How can we understand and manage rapidly changing novel ecological systems that differ fundamentally from those that were formed through long-term ecoevolutionary processes?
- *Socioecological Systems*: How can we better understand and embrace the role of humans as embedded ecological actors of socio-ecological systems?
- *Biophilia in the Anthropocene*: How can we strengthen new bonds between humans and nature in the Anthropocene?

Articles featured in the Virtual Issue are denoted by citations set in bold type, click on the citation to read the paper and the Virtual Issue.

Papers included in this Virtual Issue are indicated by their citations set in bold type. The full collection can be accessed at: https://nph.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2572-2611.plant-sciences-for-the-anthropocene.

2 | ECOLOGICAL NOVELTY: UNDERSTANDING AND MANAGING NOVEL ECOLOGIES

At present, many ecological processes and patterns change at once and threat factors such as climate change, pollution, or biological invasions interact. Addressing threat factors individually will therefore often not work or can worsen the situation—for instance, when an invasive species is being eradicated that controlled another invasive species (e.g., Bergstrom et al., 2009). Ecological research and conservation management must address the interplay of multiple anthropogenic changes. Several articles included in this collection illustrate the multifaceted nature of contemporary environmental issues—for instance, in the case of insect pollinator decline (**Lander, 2019**) or the maintenance of urban trees (**Cavender & Donnelly, 2019**; **Esperon-Rodriguez et al., 2019**; **Turner-Skoff & Cavender, 2019**). There are several lessons learnt that can be drawn from the articles in this collection on how to deal with ecological novelty.

First, understanding individual threats remains important. Urban areas can serve as early warning systems as illustrated by **van Kleunen et al. (2019)** who demonstrate that microplastic pollutants can negatively affect plant growth. They studied the effect of plastic used in artificial sport turfs on the above- and belowground growth and competitive interaction of *Plantago lanceolata*. Urban areas can also serve as testing grounds of possible solutions; especially because human capacity to care for nature is particularly high in densely populated areas. **Esperon-Rodriguez et al. (2019)** used niche modeling to assess the vulnerability of urban forests to climate change in Australia (changes in humidity, heat, or both). They conclude that we must now start to plant the trees that are adapted to a future urban climate. Indeed, species selection by humans has been shaping urban biodiversity patterns for a long time, as their study and others included in this collection (**Avolio et al., 2019**; **Dunn, Marzano, & Forster, 2019)** show. Urban areas are an ideal place to explore what it means to design novel species assemblies and communities adapted to the environmental conditions of the Anthropocene. Naturalistic planting designers and gardeners have been experimenting with the design of diverse, resilient, and nature-like plant communities in gardens and parks for decades (e.g., Dunnett & Hitchmough, 2004).

Second, multi-methodological approaches that combine theory and controlled experiments with statistical modeling of large and often heterogeneous datasets and field research (including citizen science) are needed to understand novel and rapidly changing real-world ecological systems (Kueffer, Pysek, & Richardson, 2013). **Lander (2019)** integrated mathematical modeling of plant–pollinator networks with citizen science, **Esperon-Rodriguez et al. (2019)** combined data from local tree inventories with global biodiversity data and climate models, v**an Kleunen et al. (2019)** performed controlled experiments to detect an emerging threat, while **Dunn, Marzano, & Forster (2019)** collected social sciences data on consumer attitudes and behaviors to understand species movements through plant trade. **Edmondson et al. (2019)** integrated remote sensing data, fieldwork, and citizen science data to understand the productivity of a new type of human–nature system—urban agriculture.

Third, although anthropogenic ecological change is complex, many of the fundamental conservation needs remain obvious and straightforward. **Lander (2019)** argues that provisioning of diverse foraging and nesting resources and counteracting habitat loss are central to wild bee protection. **Cavender and Donnelly (2019)** emphasize that basic requirements such as sufficient soil volume, high genetic and species diversity, and good horticultural practices are fundamental for maintaining long-lived urban trees. Equally, reducing emerging threats such a microplastic pollution (**van Kleunen et al., 2019**) or plant pests and diseases (**Dunn, Marzano, & Forster, 2019**) following a precautionary approach remains a conservation priority. **Dunn, Marzano, & Forster (2019)**, for instance, were interested in a horticultural sector accreditation scheme that promotes biosecurity measures. These examples hint at a more general need of our time: to restore the social, cultural, and ecological capital of coupled socioecological systems in wild, rural, as well as urban systems (e.g., Hobbs et al., 2014; Krasny & Tidball, 2015).

3 | SOCIOECOLOGICAL SYSTEMS: HUMAN AGENCY SHAPES URBAN BIODIVERSITY

Research in invasion biology and plant health has over the past decades increasingly recognized how important it is to understand human preferences and behaviors to be able to predict and manage future species distributions in the Anthropocene. One example of such research in this collection comes from **Dunn, Marzano, & Forster (2019)** who surveyed the factors that influence the decisions of plant buyers in the UK. Such biosecurity research is based on the assumption that newly introduced species pose an ecological risk. The presence of alien species must, however, not necessarily always be negative for biodiversity. A nice example of a study that approaches urban biodiversity from a broader perspective is **Avolio et al. (2019)**. They compared in Los Angeles, USA, wild plant biodiversity in remnant natural areas with planted and cultivated plant biodiversity among urban trees and in residential yards and community gardens. They demonstrate that species diversity is markedly higher among cultivated than wild plants and conclude that "residents have created a new urban biome in Los Angeles, and this has consequences for associated organisms, ultimately resulting in a responsibility for society to determine what type of biome we wish to create". This will require a better understanding of how the health, life quality, and cultural life of urban citizens depends on urban plants and biomes as demonstrated by several articles (**DelSesto, 2019**; **Edmondson et al., 2019**; **Sachdev, 2019**; **Turner-Skoff & Cavender, 2019**). **Turner-Skoff & Cavender (2019)**, for instance, review how urban nature and especially urban trees can contribute greatly to livable and sustainable cities, including by cooling the climate. Other benefits of urban trees are that they support health and life quality, reduce stress, increase performance (e.g., learning), promote social life, and remove pollution. Urban biodiversity and ecosystem health sustain human

well-being, while human stewardship sustains urban biodiversity and ecosystem health (e.g., Krasny & Tidball, 2015).

4 | BIOPHILIA IN THE ANTHROPOCENE: ENGAGING WITH URBAN NATURE

The different ways through which people engage with nature are thus central to ecology in the Anthropocene. One of the most important human relationships with nature has for millennia been agriculture. With a growing interest in urban agriculture and gardening, food production has moved to cities. However, it has remained unclear whether urban agriculture is merely a fad or can indeed substantially contribute to food production. **Edmondson et al. (2019)** report on a citizen science project in the UK (MYHarvest) that aims to collect comprehensive data on fruit and vegetable production by urban dwellers. Beyond contributing to food security, urban gardening projects are an important way of strengthening links between people and plants. Indeed, many urban citizens have largely lost their bonds with nature and ignore it, and this loss of nature awareness is stronger for plants than animals—a phenomenon that has been called "plant blindness" and is discussed in several articles in this Virtual Issue (see, for instance: **DelSesto, 2019**; **Nyberg, Hipkiss, & Sanders 2019**; **Sachdev, 2019**; **Turner-Skoff & Cavender, 2019**). **Nyberg, Hipkiss, & Sanders (2019)** aim to understand how to counteract plant blindness in designed learning environments such as in science centers, botanic gardens, or zoos. They conclude that conscious efforts are needed to make plants more visible.

Our perception of plants in urban environments is, however, not merely psychological and cognitive, it is embedded in sociopolitical and cultural contexts. **Aloi (2019)** discusses how a grove of palm and banana trees in a public space in front of Milan's cathedral triggered strong reactions related to questions of national and multicultural identities. **Sachdev (2019)** collected through her ethnographic work many examples of plant motifs used in street art and on design objects of craftspeople in India. Many of these plant paintings have a religious significance. **DelSesto (2019)** is interested in the potential of plant–people interactions to transform individuals and communities. By referring to the concept of ecological self, he argues that meaningful and sensual experiences with plants can contribute to the development of a personal identity that is shaped not only by inner psychological factors and social interactions but also by encounters with plants and nature. There is great potential for new interdisciplinary explorations at the intersections of the arts, cultural sciences, and ecology expanding on the tradition of fields such as ethnobotany (Kueffer, 2017; Marchese, 2015; Sanders, 2019). Ultimately, ecology is tightly linked with broader societal issues such as sustainability and environmental justice (e.g., Agyeman & Evans, 2003; Krasny & Tidball, 2015).

5 | CONCLUSIONS

The papers brought together in this Virtual Issue show how rich plant research in urban areas has become. They point out some of the main pillars of an emerging paradigm of an ecology of the Anthropocene or—in the words of the mission statement of *Plants*, *People*, *Planet*—of how to "put plant focused research firmly in the context of its wider relevance to people, society and the planet". These are three key insights for an ecology of the Anthropocene that I gained from this collection of papers:

First, theoretical insights and new analytical and methodological developments from basic research must be integrated with field and applied research and with participatory processes such as citizen science to understand ecological novelty. The separations of basic from applied ecology, laboratory from field research, and science from application might have become anachronistic. Future ecology will be hybrid and bridge between different research cultures and types of experts.

Second, urban ecosystems—and more generally socioecological ecosystems in the Anthropocene—are characterized by tight feedbacks between biodiversity (**Avolio et al. 2019**; **Cavender & Donnelly, 2019**; **Esperon-Rodriguez et al., 2019**; **Lander, 2019**) and how we perceive it (**Aloi, 2019**; **Nyberg, Hipkiss, & Sanders, 2019**), communicate about it (**Sachdev, 2019**), let it influence ourselves (**DelSesto, 2019**; **Turner-Skoff & Cavender, 2019**), and in turn shape it (**Dunn, Marzano, & Forster, 2019**; **Edmondson et al., 2019**; **van Kleunen et al., 2019**). This requires more interdisciplinarity between ecologists and social and cultural scientists.

Third, a managerial approach to nature conservation that intends to reach specific targets through planned interventions based on disciplinary scientific evidence from the biological sciences is a too narrow vision for the healing of our relationships with nature in our time of biodiversity loss and overexploitation of the planet. We need to develop new bonds with nature and work toward a new ethic and culture of stewardship for nature (e.g., Krasny & Tidball, 2015). This will require hybrid thinking at the intersections of ecology, social and cultural sciences, planning and design, social, cultural and artistic practice, ethics and religion, and civil society.

KEYWORDS

Anthropocene, biophilia, ecological novelty, ecosystem services, interdisciplinarity, plant–people interactions, socioecological systems, urban ecology

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