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Amin Rastandeh & Meghann Jarchow

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COMMENTARY AND DEBATE

Urbanization and biodiversity loss in the post-COVID-19 era: complex challenges and possible solutions

Amin Rastandeh and Meghann Jarchow

Department of Sustainability & Environment, University of South Dakota, Vermillion, SD, USA

ABSTRACT

Although biodiversity conservation and restoration can significantly contribute to environmental health in urban areas, rapid urbanization undermines biodiversity in various ways. We hypothesize that one challenge that will arise after the COVID-19 pandemic is the accelerated expansion of urban areas through two distinct mechanisms: more informal settlements due to increased poverty and increased urban sprawl due to increased suburban development. In response to this challenge, we call for a global agenda to put the concept of wildlife-supportive green space design into action. We suggest 12 major issues for future research and practice that should be scrutinized in the post-COVID-19 era.

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Urbanization and biodiversity

Humans have become an urban species, with more than half of the world's population now living in urban areas. As people move into cities to take advantages of greater employment opportunities, the direct impacts of urbanization on biodiversity have increased. Although biodiversity can significantly contribute to environmental health (i.e. the health of abiotic, biotic, and cultural resources) in cities, urbanization undermines biodiversity directly through habitat degradation (Elmqvist *et al.* 2013), and these impacts are compounded by the fact that cities are often established at areas of biodiversity significance (i.e. ecosystem junctions; Alvey 2006). For example, biodiversity-rich coastal zones have experienced more rapid urban expansion than other ecosystems (Elmqvist *et al.* 2013). The direct footprint of urban areas is a very small fraction of the ice-free land surface globally, yet the indirect footprint of urban areas on resource use and biodiversity are far greater. Habitat loss and destruction due to resource extraction and food production, mainly for consumption in cities, is a primary cause of biodiversity loss. Climate change is another primary driver of biodiversity loss, and urban areas are responsible for > 75% of global CO₂ emissions (Seto *et al.* 2014). Therefore, slowing and reversing biodiversity loss requires strategic management within and outside of cities, and the current COVID-19 pandemic provides some unique insights into biodiversity conservation and restoration while also presenting potential future challenges.

The COVID-19 and urban biodiversity

The global response to COVID-19 has demonstrated the rapid and significant impact that reduced human activity can have on the environment. For example, satellite-measured NO₂ concentrations over China were 10–30% lower from 10–25 February 2020 compared to the same time period the previous 15 years (NASA 2020), and there are anecdotes of wildlife using urban spaces due to reduced human activity; yet most of these phenomena are expected to dissipate once economic and social activity return to pre-pandemic levels. The longer-term implications of the COVID-19 pandemic on biodiversity, however, are uncertain. We hypothesize that one challenge that will arise after the pandemic is the accelerated expansion of urban areas through two distinct mechanisms: more informal settlements due to increased poverty and increased urban sprawl due to increased suburban development.

Crisis in informal settlements

Currently, some 25% of the world's urban population (i.e. > 1 billion people) live in informal settlements, mainly due to widespread poverty in less developed and developing countries (UN-Habitat 2019). The post-COVID-19 era associated with a new wave of poverty will likely force more humans in less developed or developing countries to move into informal settlements. The impacts of informal settlements on the world's natural ecosystems have been well documented, more specifically in landscapes of Latin America, Africa, India, and Indonesia. Given this, we estimate that a greater confrontation of informal

settlements with these ecosystems will have more severe impacts on biodiversity in the post-COVID-19 era. Although biodiversity is vital to the healthy functioning of ecosystems, the importance of addressing other challenges such as food security, safety, and sanitation outweighs the significance of safeguarding biodiversity in informal settlements. Thus, we believe that conserving and restoring biodiversity will not be an urgent priority in these areas, at least in the near future. To overcome the ill-effects of unemployment and poverty, residents of informal settlements may extract and overuse natural resources more than before. Land-cover change and deforestation will occur around informal settlements at a higher rate and human activities in these areas will cause a greater degree of soil/water pollution, accordingly. This over-extraction of natural resources by residents of informal settlements will accelerate the process of biodiversity decline in urbanized landscapes of the developing world, low-income communities, and many small island nations.

Increased suburban development

Following the bombing of the World Trade Center buildings in New York City in 2001, a well circulated article stated 'If there are to be new rules for the new warfare, one of the first is surely this: Density kills ... Density is a problem that will grow only more explosive – or infectious, as the case may be ...' (Johnson 2001) This idea was recently re-stated in response to COVID-19 in the *New York Times* article 'Density is New York City's Big "Enemy" in the Coronavirus Fight' (Rosenthal 2020). In response to fears of more rapid disease spread in dense urban areas and from the greater number of remote-working opportunities identified during the pandemic, we predict that at least a fraction of wealthier social classes will choose to practice new urban-scale social distancing and self-isolation by moving out of the city and into the suburbs.

This model of low-density suburban development requires a more widespread network of roads, giving rise to further habitat degradation and fragmentation, increased emissions of GHGs, and consequently, more stress on the life-cycle of many species. These changes increase the amount of lawns, reduce habitat quality for animals, and concurrently facilitate the presence of invasive species that are detrimental to native biodiversity. In countries like New Zealand in particular, where native ecosystems are fragile and wildlife species are extremely vulnerable to invasive species, this situation can become much more sophisticated. Furthermore, climate change can worsen the situation. For example, where dense urban development is associated with water scarcity (e.g. in parts of Australia, central Iran,

Israel, North Africa, Mexico, and the southwest of the United States), urban biodiversity will face an extra environmental pressure. In highly dense urbanized landscapes of Europe, where population density is extremely high and land is scarce, the lack of regional collaborations for biodiversity conservation/restoration can lead to a continental biodiversity crisis. In countries like Australia, Canada, and New Zealand, where population density at the national level is extremely low, the average income is high, and suitable land for housing development is still abundant, the risk of urban sprawl will be high during the post-COVID-19 era.

Actions for the future

In addition to efforts to reduce the accelerated expansion of urban areas, we call for a global agenda to put the concept of wildlife-supportive green space design (Rastandeh 2020) into action. This concept originates from the theory of reconciliation ecology (Rosenzweig 2003), which suggests that the land occupied by humans should be shared with wildlife species to ensure vital ecosystem services (e.g. pollination, seed dispersal, soil health and water quality protection, energy and food supply, pest control, cultural values, human health and wellbeing; MEA 2005) within cities and across urbanized landscapes. The importance of wildlife in the production of ecosystem services is being increasingly comprehended. For example, a survey of urban residents in nine European countries shows 73% of people agree/strongly agree with the creation of habitat for wildlife in urban green spaces (Fischer *et al.* 2020). This level of social acceptance in Europe, if not across the world, can act as a platform to conserve biodiversity during the post-COVID-19 era.

As cities expand and natural ecosystems collapse, wildlife-supportive green space design should become a new normal in neighborhoods, cities, and landscapes, as well as transitional spaces, where the spatial scale changes. Inter-scale connectivity and pest and disease control are equally essential to develop a multi-scale network of green spaces for biodiversity conservation/restoration (Figure 1). As more urban land will be occupied by humans for dwelling, we need to understand how the green spaces that humans use in urbanized landscapes can concurrently function as habitats for wildlife species. Putting this concept into action is not feasible unless we develop an understanding of issues and limitations associated with it in the real world. We suggest 12 major issues for future research and practice that should be scrutinized in the post-COVID-19 era. The nature of these issues is multidimensional, accounting for various aspects of the design, planning, and governance of green spaces and involve a wide range of stakeholders:

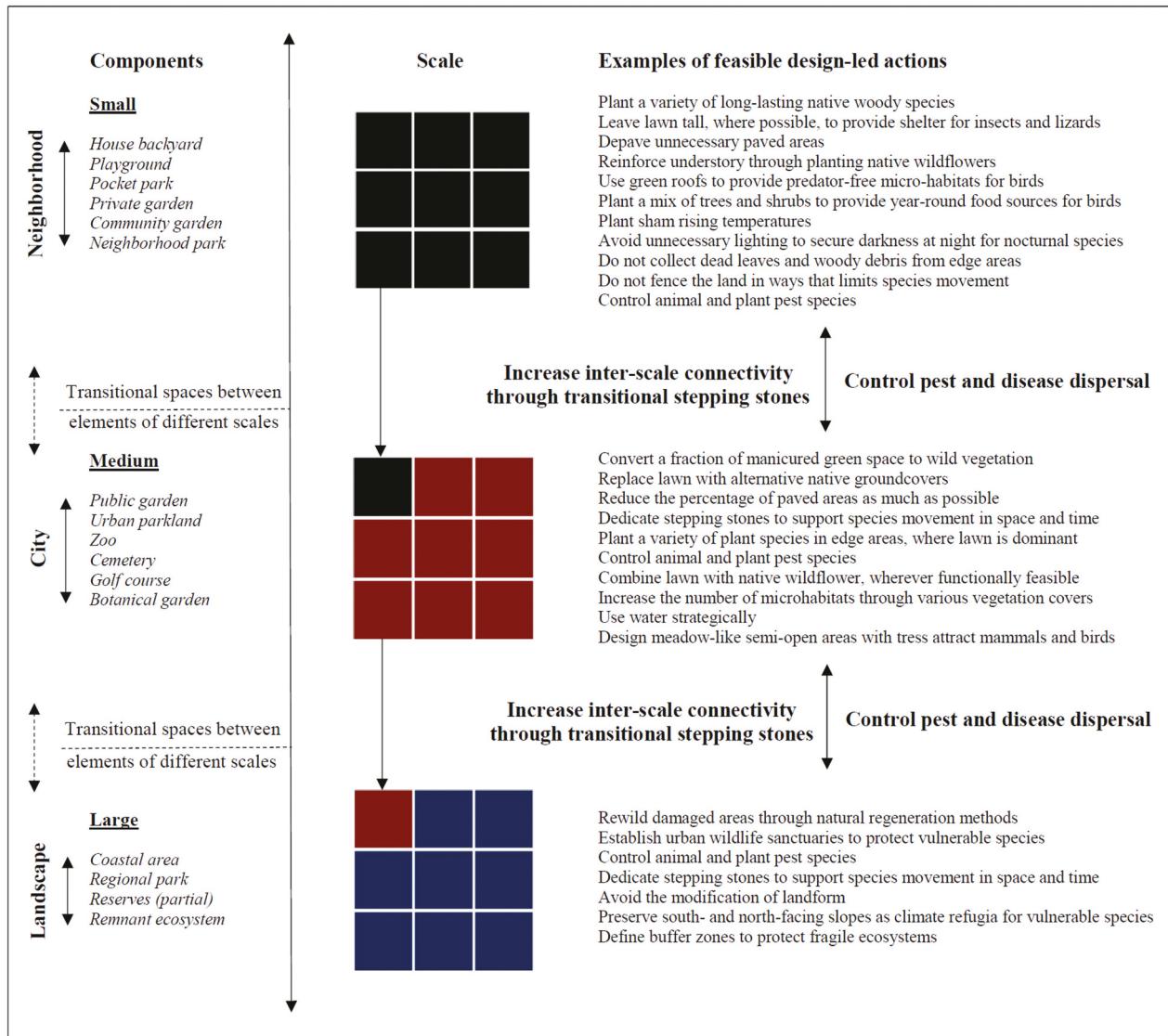


Figure 1. A conceptual framework for wildlife-supportive green space design in neighborhoods, cities, and landscapes in response to the potential urban expansion during the post-COVID-19 era.

- how to avoid zoonotic diseases, observe public health standards, and practice proper distancing while sharing green space with potentially safe native wildlife species in public and private lands in neighborhoods, cities, and landscapes;
- how to establish urban wildlife sanctuaries, micro-climate refugia, strategic stepping stones, and wildlife-friendly greenways to facilitate the persistence, colonization, and movement of wildlife species in urbanized landscapes;
- how to employ principles of wildlife-supportive green space design as a common language among researchers, professionals, urban authorities, and landowners;
- how to convert scientific findings to feasible actions to inform both residents and urban authorities of the importance of biodiversity conservation/restoration in suburbs/informal settlements;
- how to encourage landowners to redesign the structure of green spaces and dedicate a proper fraction of the land to native wildlife species;
- how to make biodiversity conservation/restoration a sustainable source of income for families in informal settlements to avoid further land-cover change and biodiversity loss;
- how to use biodiversity conservation/restoration as a catalyst to improve environmental justice and provide fair access to healthy urban nature in informal settlements;
- how to select plant species to minimize the maintenance costs of green spaces and contribute to climate comfort, biodiversity, and food security;
- how to intervene in private green spaces of neighborhoods, as small cells, to enhance the overall level of biodiversity in the urbanized landscape, as a larger system;
- how to use green roofs as predator-free micro-habitats and stepping stones for vulnerable bird species, where the presence of predator mammals is an ecological challenge;
- how to combine Indigenous knowledge and technologies with scientific facts to maximize the

positive impacts of wildlife-supportive green space design within cities and across urbanized landscapes; and

- how to employ the spatial ecology of keystone species in each region as a guideline to design/redesign green spaces that can serve as primary habitat for a broader range of native wildlife species.

These issues can be discussed in the future under the Post-2020 Global Biodiversity Framework (IUCN 2020). While the overarching goal of wildlife-supportive green space design will be the same across the world, methods, tools, and solutions should be local and site-specific. Multi- and cross-disciplinary collaborations among social, ecological, urban, and health experts/officials, as well as residents, are essential at various spatiotemporal scales to achieve this goal. If properly applied, the post-COVID-19 era, in conjunction with increased urban expansion and continued climate change, *can* become a turning point in the history of urbanization, when human decides to peacefully and strategically coexist with wildlife in a shared land: the beginning of a new era of design *with* and *for* nature in an urbanizing world.

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Notes on contributors

Amin Rastandeh is Postdoctoral Researcher in the Department of Sustainability & Environment at the University of South Dakota. He received his PhD in Landscape Architecture from Victoria University of Wellington, New Zealand. He is interested in urban and regional ecology, strategic spatial design for biodiversity conservation, and land-use land-cover assessment in multifunctional landscapes.

Meghann Jarchow is Chair and Associate Professor in the Department of Sustainability & Environment at the University of South Dakota. She is interested in sustainability as a framework through which to create a more desirable world. Her specific focus within the field of sustainability is on creating more multifunctional landscapes within the former tallgrass prairie region and in sustainability education. Her research takes an interdisciplinary approach to evaluating opportunities to enhancing the multifunctionality of this region.

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