

## Urban sustainability: an inevitable goal of landscape research

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“Sustainability” has become the word of the day and the theme of our time. The word—which in essence means meeting the needs of the present generation without compromising the ability of future generations to meet their own (WCED 1987)—tends to conjure bucolic images of landscapes with green hills and empty spaces, but that may be a mistake. Our world certainly is replete with environmental problems: biodiversity loss, ecosystem degradation, landscape fragmentation, climate change, just to name a few. Urbanization—the spatial expansion of the built environment that is densely packed by people and their socioeconomic activities—has often been held responsible for all these problems. In the recent surge of interest in sustainability, some think that urbanization is key to regional and global sustainability, whereas others regard urban sustainability as an oxymoron. Is urbanization a problem or part of the solution for sustainability? Why is it relevant to landscape ecology?

### The dualistic nature of urbanization

Year 2007 was a historic moment in human civilization: we have transformed ourselves from an agrarian species to a mostly urban species. Only 2% of the world population lived in urban areas in 1800, but this number jumped to 14% in 1900 and 30% in 1950. In 2007, we crossed the 50% mark—with no signs of slowing down. Clearly, urban areas have become the primary habitat for humans—cities, increasingly, are where people live and thus where we will have to make sustainability a reality.

The increasing urban nature of humanity has profound environmental, economic, and social implications for the world’s future. Urbanized areas account for about 80% of carbon emissions, 60% of residential water use, and close to 80% of the wood used for industrial purposes (Grimm et al. 2008; Wu 2008a, b). Cities suck resources from ecosystems near and far. The “ecological footprint” of a city—the land (and water) area that would be required to provide the urban population indefinitely with all the energy and material resources consumed as well as to absorb all the wastes discharged—can be tens to hundreds of times as large as its physical size (Rees and Wackernagel 1996; Luck et al. 2001). Urbanization influences local climate by creating urban heat islands on multiple scales (Buyantuyev and Wu 2010); it leads to excessive consumption and frequent contamination of water; it creates major producers of greenhouse gases and air pollutants; and

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it is the most drastic form of land transformation, devastating biodiversity and ecosystem services. In many parts of the world, urbanization is also linked to increased social inequity and poverty—the problem of “urbanization of poverty”.

Yet, cities epitomize the creativity, imagination, and mighty power of humanity. Cities are the centers of socio-cultural transformations, engines of economic growth, and cradles of innovation and knowledge production. Cities are magnificent for the splendid architectures that symbolize them, inspirational for the fascinating stories of human civilization that enrich them, and attractive for the opportunities and comforts that they offer. And, perhaps most importantly, urbanization offers a number of things that are critical to achieving sustainability.

The most remarkable thing about cities is that, even with urban sprawl, they take up merely 3% of the earth’s land surface, but accommodate more than half the world’s population. Cities have lower per capita costs of providing clean water, sanitation, electricity, waste collection, and telecommunications, and offer better access to education, jobs, health care, and social services. Try to imagine a world with nearly 7 billion but no cities. How much intact habitat would there be left for other biological species? What would happen to the economy and society, locally and globally? Could that be a more sustainable world?

### Urban sustainability and landscape ecology

All the urban problems mentioned earlier do exist, indicating that most, if not all, our cities are unsustainable. These problems will get worse if we continue to allow urbanization to unfold haphazardly without consideration of long-term environmental and socioeconomic consequences. To achieve sustainability, therefore, we need to design and build better cities, and explicitly consider urbanization as part of the solution to regional and global sustainability. The former Secretary-General of the United Nations, Kofi Annan, said it well: “The future of humanity lies in cities.”

Cities are the most heterogeneous landscapes. Urban sustainability is fundamentally the sustainability of the urban landscape as a whole. As such, it has much to do with the composition and configuration of

the urban landscape that always extends beyond the city limit. From the widely quoted notion of the “triple bottom line sustainability,” a sustainable city must achieve a balance among environmental protection, economic development, and social wellbeing. Urban sustainability requires minimizing the consumption of space and resources, optimizing urban form to facilitate urban flows, protecting both ecosystem and human health, ensuring equal access to resources and services, and maintaining cultural and social diversity and integrity (Alberti and Suskind 1996; Spiekermann and Wegener 2003; Wu 2008b). This interpretation of urban sustainability is generally consistent with the six E’s of landscape sustainability—environment, economy, equity, aesthetics, experience, and ethics, as discussed by Musacchio (2009a).

If the creation of cities is one of the most remarkable human achievements to date, developing sustainable cities may well be the grandest challenge to humans ahead. No recipe is available, but it seems certain that science needs to play an instrumental role in this endeavor. To do so, natural sciences (the sciences of the natural concerned chiefly with how things are) and design sciences (the sciences of the artificial dealing with how things ought to be) must be fully integrated (Simon 1996). We must understand not only the natural landscapes but also the landscapes we create; we must understand not only how landscapes work but also how they can work better, if we are to develop a sustainable suture. Landscape ecology provides both a pluralistic theater and a diversity of players for such interdisciplinary and transdisciplinary enterprise. As Richard Forman (2008) has argued:

What would you use as the central foundation or perspective to change the land, shape the future, for nature and us? Economics? Water resources? Transportation? Housing and employment? Bioconservation? Engineering? Social structure? Agriculture? Architecture? Each has obvious strengths and major lacks for the challenge. No panacea exists. I keep searching and still can discover no better foundation than landscape ecology.

Urban sustainability, although its precise definition may forever be debatable, has become an inescapable goal of landscape ecology. Individual landscape

ecologists may choose certain aspects of the landscape to study, but the field as a whole has to answer the call of our time. Indeed, perspectives that emphasize the relevance and importance of landscape ecology to sustainability in general and urban development in particular have increasingly been advocated by landscape ecologists (e.g., Potschin and Haines-Young 2006; Wu 2006, 2008b; Iverson 2007; Naveh 2007; Opdam 2007; Nassauer and Opdam 2008; Pickett and Cadenasso 2008; Barrett et al. 2009; Musacchio 2009a; Termorshuizen and Opdam 2009; Pijanowski et al. 2010). Several recent special issues of this journal, *Landscape Ecology*, have focused on the ecology and sustainability of urban areas, including:

- “Landscape Ecology: An Integrated Science for Sustainability in a Changing World,” edited by Pearson and McAlpine (in review)
- “The Ecology and Culture of Landscape Sustainability,” edited by Musacchio (2009b)
- “Integrated Modelling of Natural and Social Systems in Land Change Science,” edited by Milne et al. (2009)
- “Applying Landscape Ecological Principles in Urban Environments,” edited by Breuste et al. (2008)

While landscape ecology is increasingly considered relevant to sustainability, its contribution to the science and practice of sustainability is rather limited up to date. To move forward, a number of research questions may be addressed:

- What theories, principles, and methods of landscape ecology are pertinent to urban sustainability? How do we operationalize them?
- How does landscape pattern or spatial heterogeneity affect urban sustainability?
- How do ecological, economic, and social patterns and processes in urban landscapes change with scale and interact to influence sustainability?
- How do we measure urban landscape sustainability? Are there landscape metrics that can be used as urban sustainability indicators?
- How do we develop landscape models that capture the essential components and processes of urbanization, so that they can be used to project sustainability trajectories in response to environmental, economic, social, and institutional changes?

- How can landscape ecology help design sustainable urban landscapes?

One may quickly point out that some of these questions have been studied by landscape ecologists. However, much more concerted efforts are needed to address these questions systematically and rigorously if landscape ecology is to accomplish its anticipated interdisciplinary and transdisciplinary goals. “Urban regions are ripe for the attention of landscape ecologists and allied experts” (Forman 2008). I believe that this increasing urban emphasis will provide more opportunities for developing and testing landscape ecological theories and principles, enhance the field’s interdisciplinarity and transdisciplinarity, and make landscape ecology more relevant to society and the world that changes rapidly with dynamic landscapes.

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