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Ecological science and transformation to the sustainable city

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ABSTRACT

There is growing urgency to enhance the sustainability of existing and emerging cities. The science of ecology, especially as it interacts with disciplines in the social sciences and urban design, has contributions to make to the sustainable transformation of urban systems. Not all possible urban transformations may lead toward sustainability. Ecological science helps identify components of resilience that can favor transformations that are more sustainable. To summarize the dynamics and choices involved in sustainable transformations, a "metacity" framework is presented, embracing ecological processes in cities as complementary to those involving society, power, and economy.

Introduction

Contributing to the sustainability of the biosphere through facilitating the societal dialog about Earth's future is an urgent priority for researchers (Chapin et al., 2009, 2011; Clark, 2007; Odum & Odum, 2001). The rubric of sustainability suggests an engagement across disciplines and with society, with the larger goal of improving both human well-being and the resilience of the Earth's biological foundations on which humans depend and constantly interact. Nowhere is this double commitment more needed than in the growing urban realm (Pickett, Cadenasso, & Grove, 2004; Pincetl, 2012; Sassen & Dotan, 2011). It is crucial to explore how urbanization, as one of the major contributors to global change (Vitousek, Mooney, Lubchenco, & Melillo, 1997), might be better directed toward improving the sustainability of the Earth's biosphere. However, global urbanization is not simply a conversion of wild, pastoral, or agricultural land to city and suburban cover. Urbanization also involves radical changes in the form, metabolism, economy, and demography of urban ecosystems themselves. We label such radical changes as urban transformations. Past examples of urban transformations include the fundamental restructuring of English settlements by the industrial revolution, or the conversion of Chicago from a fur trading center to a major subcontinental rail and meat processing hub. Our approach also recognizes that these urban transformations are embedded in broader socio-ecological processes that transform rural lands and livelihoods as well (Williams, 1975).

We draw on biological ecology, social sciences, and urban design to examine a variety of possible urban transformations and the ways in which such transformations might support or inhibit urban sustainability. A shift in the form and dynamics of urban areas toward sustainability would indeed be a radical and, we assume, positive transformation (Curwell, Deakin, & Symes, 2005). This paper presents three themes: (1) the diversity of urbanization around the globe can identify inflection points in the trajectories of urban change where ecology can contribute, (2) there are many actual and potential transformations that cities can undergo, and (3) a social–ecological-design vision can help move cities toward sustainability through the processes of resilience. These three themes are developed through the following steps. First we provide a brief overview of the global trends in urbanization that set the context for understanding urban transformations, which are triggered by both crises and opportunities that open the way for enhanced urban sustainability. Second, we examine how ecological processes might contribute to urban sustainability and may help favor this transformation among the many possible trajectories of urban change. Third, we develop a framework that accounts for the variety of urban forms now emerging around the globe, in order to promote the interdisciplinary work needed to support sustainable urban transitions. This analysis is intended to better inform choice among the possible courses of action aimed at increasing urban sustainability.

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The global urban tide: the context for urban transformations

Urban lands exhibit a wide variety of forms around the world. Even within regions they span diverse kinds of fabrics, from traditional north temperate mosaics encompassing city centers to sparse exurbs, while in the Global South, city form often includes informal settlements such as slums, favelas, and shantytowns (Fig. 1). This spectrum of urban areas is already home to more than half of the world's population, and according to the United Nations, will accommodate more than 80% of all people in but a few decades. This remarkable urban tide is driven by population increase and migration, as well as by the less visible requirements of global institutions and finance (Sassen, 2001). The world population is projected to add three billion people before stabilizing at around 10 billion in the coming decades. This increase is equivalent to the number of new urban residents projected over that same time period (United Nations Population Fund, 2007). Effectively all new people on the planet will be urbanites, and most will be living in developing countries.

People are drawn to cities by the perceived amenities they provide, such as the promise of jobs, the access to education, or the desire for a healthier and easier life (Glaeser, 2011). For many, cities are the only option, as environmental hazards, conflict, and reduced access to traditional livelihoods make rural life ways untenable. Many governments have tried to halt the urban tide, often by outlawing urban migration outright or by declining to provide services for residents of unauthorized or impromptu urban settlements (United Nations Population Fund, 2007). Still the tide continues (Fig. 2).

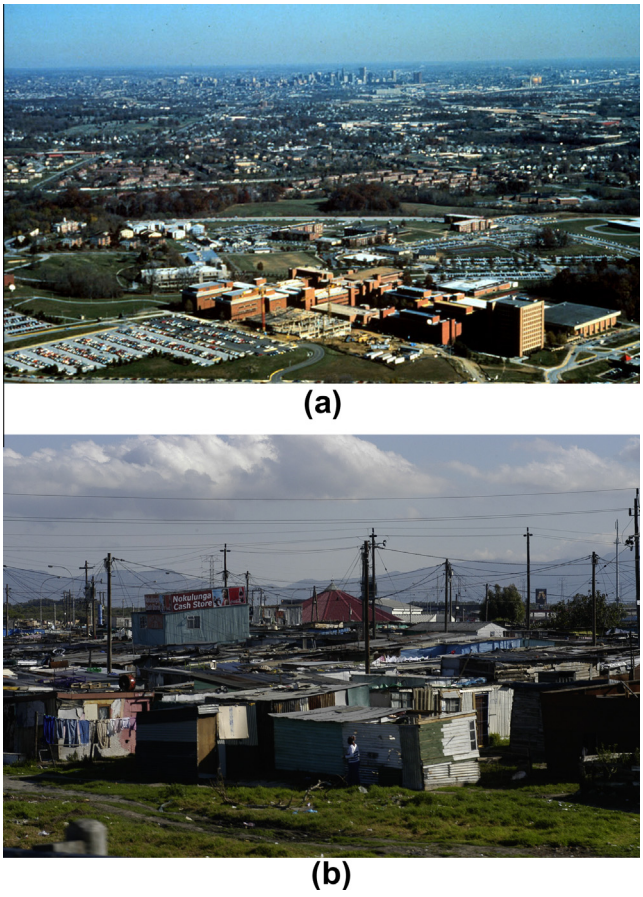

Fig. 1. Two contrasting examples of global urban form. Left panel: an oblique aerial view of Baltimore, MD, US, representing a post-industrial city. Right panel: an informal settlement in Cape Town, South Africa illustrating an increasingly common element of rapidly growing cities. Photo A courtesy of UMBC; Photo B, (c.) S.T.A. Pickett.

How will cities differ in the future? First of all, the sheer number of cities will increase. Such increase includes cities established *de novo*. Second, the maximum size of cities will continue to increase. The United Nations (2007) calls cities with more than 20 million residents "metacities" or "hypercities." These coinages reflect "city inflation," since in the past the largest category of cities was the "megacity," which exceeded a mere 10 million people. In spite of the growth of the largest cities, the majority of urban growth will occur in medium-sized cities that have from 500,000 to 1 million people (United Nations Population Fund, 2007). This is not necessarily a good thing, as smaller cities in the Global South may not have the resources to provide healthy, well-functioning systems. However, smaller cities are likely less "path dependent" and carry less inertia of fixed investments (Childers, Pickett, Grove, Ogden, & Whitmer, 2013; Ernstson et al., 2010). It is such intermediate sized cities that may be better poised to employ new, more sustainable ideas (Childers et al., 2013). In other words, small to medium sized cities may "leap-frog" traditional urban structures and functions to advance more effectively along sustainable trajectories.

As cities grow in extent and size, simple views of cities are less useful. Classically, cities have been conceived as having a dense core, in which most non-residential functions are concentrated, surrounded by rings of less and less dense residential and minor commercial or manufacturing functions. In the industrialized world today, the density profiles of urban areas are flattening as they spread. That is, urban mosaics of commerce, industry, residence, and transportation extend farther into the countryside while old city centers thin. Furthermore, the business, commercial, and industrial functions that were once the purview of the central city have been dispersed broadly, and are now served by sprawling highway networks in peri-urban areas (Garreau, 1991; United Nations, 2007). Even in the Global South, the human connections between city cores and distant settlements generate urban-like rural areas (McHale, Bunn, Pickett, & Twine, 2013). Moreover, globalization has engendered new forms of political and economic governance, resulting in unprecedented urban global interdependency and connection (Sassen, 2001).

Crisis versus opportunity: crucible of transformation

These staggering facts, figures, and projections can be read as a distress signal. However, a more positive perspective is possible. The current state of urbanization presents the opportunity for transformation. The science of ecology has contributions to make toward goals of urban sustainability through understanding and helping design and manage existing and emerging cities (McGrath et al., 2007; Spirn, 2001). To make such contributions, it is necessary to understand the kinds of transformations that cities can experience. What can be learned from past transitions which can promote future urban transformations that are better informed by sustainability? Understanding urban transformation also requires an articulation of what systems are transforming *from*. We identify these below as city modes. Potential transitions between different city modes represent inflection points – the periods or places where urban change can be turned in more resilient directions to support sustainability goals. These inflections are also situations where ecological information can be especially helpful.

A classical model of urbanization links the evolution of cities with industrialization. This model, based on the experience of cities in the Global North, starts with cities as mercantile settlements, fueled by craft and trade. The second phase of urban development was stimulated by industrialization. As industry was introduced and grew, city population increased to staff the factories, and the economy shifted to focus on the concentration and conversion of