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Nature, urban development and sustainability – What new elements are needed for a more comprehensive understanding?

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ABSTRACT

With the rise of interest in urban sustainability, the question of nature is front and center. This review suggests bridging between three distinct research paths concerned with urban areas and nature: urban ecosystem services, urban metabolism and urban political ecology to forge new thinking to transition from the sanitary city of the twentieth century to the sustainable city of the twenty-first. Cities are anthropogenic creations, sourcing their materials from nearby and far-off places, transforming those materials into products, goods and the physical infrastructure of cities. Tracking that flow of nature into the built environment, and the other flows such as water, needs to be accounted for as part of nature in the city. Cities – having entirely transformed the place they are located through building – have a unique nature, a nature planted by people, and made up of plants and animals that are often different than what had existed in the first place. The services of this new assemblage of species in the city, need to be studied critically. But ultimately, cities are the product of human volition, driven by economics, culture, politics and history. Understanding those drivers – the political ecology of place – provides an interpretive framework for reconsidering the nature of cities and its place in moving from a modernist sanitary city to a gray/green sustainable city.

Introduction

To transition from the sanitary city of the twentieth century to the sustainable city of the twenty-first, new knowledge needs to be developed and applied to understanding the role of nature in cities and in supplying the resource requirements for their growth. Cities are, of course, human creations, a big factor in contributing to the drivers of human ecological geochemical change (Vitousek, Mooney, Lubchenco, & Mellilo, 1997). This review suggests bridging between three distinct research paths concerned with urban areas and nature: urban ecosystem services, urban metabolism and urban political ecology.

The demands of cities on Earth systems' to provide resources to cities are ever increasing and there have been numerous studies that show urban dwellers depend on the productive and assimilative capacities of ecosystems well beyond their boundaries (Deutsch & Folke, 2005; Folke, Jansson, Larsson, & Costanza, 1997; Folke et al., Grimm et al., 2008; Kennedy, Pincetl, & Bunje, 2010; Wackernagel & Rees, 1996). Ecologists, long concerned with human impacts on ecosystems, developed the Millennium Ecosystem Assessment (MEA, 2005) to highlight and codify ecological and socio-economic contributions of ecosystem services to humans.

Because of the size and impact of cities, there has been increasing attention to the potential for cities to remediate some of their own environmental impacts and reduce far-flung resource imports, using ecosystem services such as tree canopy cover, and developing heretofore underutilized or undeveloped autochthonous resources such as water (Beatley, 2010; Platt, 1994, McPherson, Simpson, Peper, Maco, & Xiao, 2005, Pataki et al., 2011; Pincetl, Gillespie, Pataki, Saatchi, & Saphores, 2012). Urban ecosystem services analysis rests on the framework of the MEA and applies its categories to urban areas.

Another literature has focused on urban metabolism—the quantification of inputs, outputs and storage of energy, water, nutrients, materials and wastes of urban regions (Baccini, 1997; Barles, 2009; Kennedy et al., 2010 among others). This literature attempts to track the actual quantities of nature that are appropriated by humans and used to sustain urban systems. Industrial ecologists have been at the forefront of this work and have used several methods to measure flows, such as mass balance. Life cycle analysis is also now being integrated into urban metabolism (Chester 2010).

Urban political ecology offers another perspective on how cities appropriate nature and organize their activities, focusing on structures of power and money to understand the appropriation of nature by economic and political agents and the distribution of flows (Keil & Boudreau, 2006; Pincetl, Jonas, & Sullivan, 2011; Swyngedouw, 2006). Thus a number of intellectual strands focus on nature

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and cities, coming from different intellectual traditions. This review attempts to build a more unified approach, drawing from each of these separate strands of research to suggest that the complex spectrum of humanly modified nature—from the city to its hinterlands—requires the development of a concept of urban ecosystem services that does the following: integrates the built environment (Moffatt & Kohler, 2008), regards urban ecosystems as novel ecosystems (Francis, Lorimer, & Raco, 2011) for an ecology *of* the city (Grimm et al., 2008 make a distinction between ecology *of* the city and ecology *in* the city), and understands the political and economic ramifications of these flows. The review then points to the elements for this more inclusive theoretical framework to address the relationship of nature and cities.

Ecosystem services

In the 1990s, researchers began to try to explicate and quantify the value of the world's ecosystem services and natural capital (Costana et al., 1997; Hawkin, Lovins, & Lovins, 1999). The value of ecosystem services, it was argued, is not fully captured in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital, and thus not given enough consideration in policy decisions (Costana et al., 1997, p. 253). Work began to delineate ecosystem functions and services and their critical importance for the functioning of the earth's life support system, and for humans. In 1997 Costanza and his colleagues estimated the value of 17 ecosystem services in 16 biomes to be in the range of US$16–54 trillion. Daily's popular 1997 edited volume on *Nature's Services, Societal Dependence on Natural Ecosystems* was another milestone in drawing attention to the importance of ecosystem services to human survival and well being. By 2005, the Millennium Ecosystem Assessment (MEA), a synthesis by over a thousand of the world's leading biological scientists of the services to humans provided by ecosystems and the impacts of humans on their health, provided a codified framework for the categorization of ecosystem functions. The MEA assessed the consequences of ecosystem change for human well-being. From 2001 to 2005, MEA scientists worked to provide a state of the art scientific appraisal of the condition and trends of the world's ecosystems and the services they provide, as well as the scientific basis for action to conserve them sustainably (http://www.maweb.org/en/index.aspx).

In the US, concern among biophysical scientists about understanding ecosystem services and human impacts on those services contributed to the creation of the National Science Foundation Long Term Ecological Research (LTER) network, established in 1980 "to provide the scientific community, policy makers, and society with the knowledge and predictive understanding necessary to conserve, protect, and manage the nation's ecosystems, their biodiversity, and the services they provide" (http://www.lternet.edu/mission/). There are now 26 research sites, including urban sites in Phoenix and Baltimore. These two sites have generated studies on urban biodiversity, hydrology, and other aspects of ecological processes, as well as coupled human-ecological (or socio-ecological) research looking at such factors as the distribution of vegetation and its function, water use and runoff in the urban environment, air pollution patterns and corresponding human social dynamics (Pickett et al., 2008).

Ecosystem health and viability were also an important component of the 1987 Brundtland Commission report *Our Common Future*. It is useful to remember that the report was the culmination of a UN commissioned study on environment and development problems, which emerged from the 1972 Stockholm Conference on Human Development and the 1980 World Conservation Strategy for the Conservation of Nature. The purpose was to draw attention to the environmental impacts of growth and raise the awareness for the need for sustainable development such that ecological collapse and human hardship would be avoided. While urban areas were not at the core of the report's analysis and recommendations, there was a call for a new agenda – Agenda 21 – for cities as well, so that they would develop more sustainably. Together, ecosystem valuation, and sustainability ushered in by the Brundtland Commission, lay the groundwork for attention to cities and their environmental impacts, as well as their potential to develop more sustainably. In 1995 William Rees, co-author of *Our Ecological Footprint: Reducing Human Impact on the Earth* (1996), Boone and Modarres (2007) (and others subsequently) suggested that it is in cities that the greatest opportunities to make the changes necessary for general sustainability can be found. Planners such as Scott Campbell included environmental thinking as part of sustainable thinking for cities, including bioregionalism as a guiding principle (1996) as did Timothy Beatley and Manning (1997) among others. Gradually cities themselves have become legitimate sites of ecological and sustainability research, linking sustainability to ecosystem services, such as tree canopy cover.

Urban ecology

Interest in the remediative role of nature in the city has had a slow and steady history since the rise of the industrial city, including some of the early designs of Fredrick Law Olmsted using water features in urban parks to remediate water pollution, and his advocacy of parks as "lungs" to counter pollution. Ebenezer Howard's Garden Cities, LeCorbusier's "Contemporary City," and Frank Lloyd Wright's Broad Acre City plan reflected ideas of the importance of urban nature as well, and urban designers and ecologists such as Ian McHarg (Design With Nature, 1971) and Anne Spirn (The Granite City, 1984), planners such as Rutherford Platt (1994), and open space advocates like Charles Little (1992), took up the refrain in the second half of the 20th century. These latter thinkers advocated that nature should be considered both in designing new urban development (watersheds and their functions, for example), and in the disposition of buildings in cities to enhance natural elements such as cooling winds in hot summers, or increasing the availability of sunlight in the winter. In the 2000s there was an explosion of interest in the distribution of parks and open space relative to the equitable provision of ecosystem services (Boone, Buckley, Grove, & Sister, 2009; Heynen, Perkins, & Roy, 2006; Pincetl, 2010; Wolch, Wilson, & Fehrenbach, 2005). This was paralleled by the study of urban landscapes (biodiversity, ecosystem function), the valuation of tree canopy cover sponsored by the Forest Service (McPherson et al., 2005, Nowak & Dwyer, 2007), and studies of watersheds and many urban ecosystem processes (Andersson, 2006; Cadenasso et al., 2008; Groffman et al., 2002; Kaushal et al., 2008; Pickett, Buckley, Kaushal, & Williams, 2011). The inclusion of two urban regions in the National Science Foundation LTER network greatly enhanced coupled socio-ecological studies of urban nature, as general principles of ecological science were applied to cities.

Yet it could be argued that urban ecosystems and their functions are themselves highly modified, reconfigured and compacted in space in the urban fabric. To build cities, profound transformations of the environment and ecological processes take place (Olson, 1980). Earth is moved and reconfigured, plants and animals are extirpated and replaced by buildings, roads and infrastructure. Parks and other vegetated open spaces are then re-implanted upon this radically rearranged land, according to a set of culturally based objectives, such as for real estate value enhancement, recreation or beauty. As such, urban nature is a *novel* ecosystem, largely created and implemented by humans. Admittedly there are biophysical constraints such as climate zones and soils, but other constraints,