Journal of Environmental Management 92 (2011) 331–362

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

Review

Urban ecological systems: Scientific foundations and a decade of progress

S.T.A. Pickett [a,*], M.L. Cadenasso [b], J.M. Grove [c], Christopher G. Boone [d], Peter M. Groffman [a], Elena Irwin [e], Sujay S. Kaushal [f], Victoria Marshall [g], Brian P. McGrath [h], C.H. Nilon [i], R.V. Pouyat [j], Katalin Szlavecz [k], Austin Troy [l], Paige Warren [m]

[a] Cary Institute of Ecosystem Studies, Box AB, Millbrook, NY 12545, USA
[b] Department of Plant Sciences, University of California, Davis, Davis, CA 95616, USA
[c] USDA Forest Service, Northern Research Station, Burlington, VT, USA
[d] School of Human Evolution and Social Change, Arizona State University, Tempe, AZ 85287-2402, USA
[e] Department of Agricultural, Environmental, and Development Economics, The Ohio State University, Columbus, OH 43210, USA
[f] University of Maryland, Chesapeake Biological Laboratory, Solomons, MD, USA
[g] Parsons, The New School for Design, and Till Design, USA
[h] Parsons, The New School for Design, and Urban Interface, LLC, USA
[i] Fisheries and Wildlife, University of Missouri, Columbia, USA
[j] USDA Forest Service, Research & Development, Washington Office, WA, USA
[k] Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218, USA
[l] University of Vermont, Rubenstein School of Environment and Natural Resources, Burlington, VT 05405, USA
[m] Department of Natural Resources Conservation, University of Massachusetts, Amherst, MA 01003-9285, USA

ARTICLE INFO

Article history:
Received 22 July 2009
Received in revised form
22 July 2010
Accepted 22 August 2010
Available online 20 October 2010

Keywords:
Animal
Biodiversity
City
Design
Ecosystem
Environment
Human
Land use
Plant
Spatial heterogeneity
Socioecological
Suburban
Theory
Urban
Urbanization

ABSTRACT

Urban ecological studies, including focus on cities, suburbs, and exurbs, while having deep roots in the early to mid 20th century, have burgeoned in the last several decades. We use the state factor approach to highlight the role of important aspects of climate, substrate, organisms, relief, and time in differentiating urban from non-urban areas, and for determining heterogeneity within spatially extensive metropolitan areas. In addition to reviewing key findings relevant to each state factor, we note the emergence of tentative “urban syndromes” concerning soils, streams, wildlife and plants, and homogenization of certain ecosystem functions, such as soil organic carbon dynamics. We note the utility of the ecosystem approach, the human ecosystem framework, and watersheds as integrative tools to tie information about multiple state factors together. The organismal component of urban complexes includes the social organization of the human population, and we review key modes by which human populations within urban areas are differentiated, and how such differentiation affects environmentally relevant actions. Emerging syntheses in land change science and ecological urban design are also summarized. The multifaceted frameworks and the growing urban knowledge base do however identify some pressing research needs.

1. The urban world

Urbanization is a dominant demographic trend and an important component of global land transformation. More than half of the planet’s population now lives in cities, up 30% from 50 years ago, and urban areas are gaining 67 million people per year. By 2030, approximately 5 billion people are expected to live in urban areas, or 60% of the projected global population of

* Corresponding author. Tel.: +1 845 677 7600x130; fax: +1 845 677 5976.
E-mail addresses: picketts@caryinstitute.org (S.T.A. Pickett), mlcadenasso@ucdavis.edu (M.L. Cadenasso), mgrove@fs.fed.us (J.M. Grove), Christopher.G.Boone@asu.edu (C.G. Boone), groffmanp@caryinstitute.org (P.M. Groffman), irwin.78@osu.edu (E. Irwin), kaushal@cbl.umces.edu (S.S. Kaushal), vm@tilldesign.com (V. Marshall), McGrath@newschool.edu (B.P. McGrath), nilonc@missouri.edu (C.H. Nilon), rpouyat@fs.fed.us (R.V. Pouyat), szlavecz@tardis.pha.jhu.edu (K. Szlavecz), atroy@uvm.edu (A. Troy), pswarren@nrc.umass.edu (P. Warren).

0301-4797/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jenvman.2010.08.022

8.3 billion. Over the next 25 years, rural populations are expected to decline, meaning that *all* population growth will occur in urban areas (United Nations Population Fund, 2007). The developed nations have more urbanized populations; for example, close to 80% of the United States' (US) population is urban. Urbanization has also resulted in a dramatic rise in the size of cities: over 300 cities have more than 1,000,000 inhabitants and 20 "megacities" exceed 10 million. The increasing population and spatial prominence of urban areas is reason enough to study them. An even more compelling argument for understanding how cities work ecologically is the need for information for decision makers involved in regional planning or conservation, for example. Proper management of cities will ensure that they are ecologically, economically, and socially more sustainable places to live in the future (Platt, 1994).

In addition to its global reach, urbanization has important effects in regions (Forman, 2008; Grimm et al., 2008). For example, in industrialized nations, the conversion of land from wild and agricultural uses to urban and suburban occupancy is growing at a faster rate than the population in urban complexes. Thus, urban areas increasingly interdigitate with wild lands. Cities are no longer compact, isodiametric aggregations, but rather sprawl in fractal or web-like configurations (Makse et al., 1995; Batty, 2008). Indeed, even for many rapidly growing metropolitan areas, the suburban zones, or "boomburgs" (Lang and LeFurgy, 2007), are growing much faster than other zones (Katz and Bradley, 1999). These new forms of urban development (Fig. 1), including exurbs, edge cities (Garreau, 1991), and housing interspersed in forest, shrubland and desert, bring people possessing urban financial equity, habits, and expectations into daily contact with habitats formerly controlled by

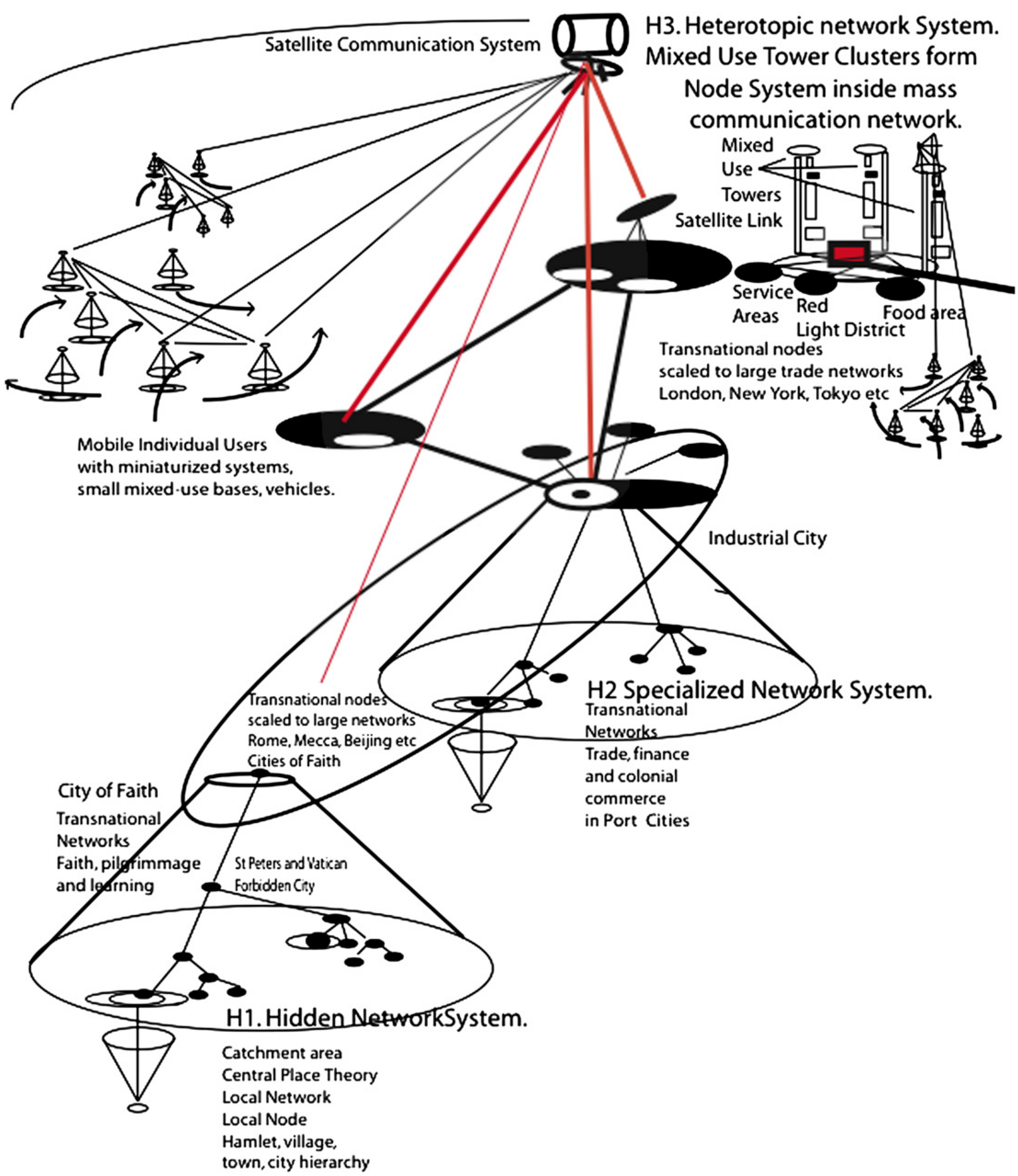

Fig. 1. A new city form representing global connections and communications, and local discontinuities. Four overlapping models operate in different combinations to form the emerging, highly differentiated patchworks, linked together to create a new global city. Compressed layers of networks flattened in the meshwork city can all be present in a particular city simultaneously, represented as a series of patches containing different systems of organization, depending on the power of particular urban actors in each city network or mesh. Used with permission of Prof. G. David Shane.