

Interdisciplinary foundations of urban ecology

Robert F. Young

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Abstract Researchers have identified urban ecology as a new field integrating social and ecological science. Critics have portrayed the field as under-theorized with negative implications for research and urban environmental planning. Unprecedented urbanization and historical bias against research integrating social and ecological systems are identified as driving this deficit. Researchers have called for new integrative approaches to address this issue. In response, this paper applies ecology’s analytic framework of “patch dynamics”, Kuhn’s concept of “normal science” and Mazoyer and Roudart’s “evolutionary series” to demographic data and historical texts to perform an analysis of interdisciplinary contributions to theory applicable in the field of urban ecology. The subsequent exploration reveals a rich history of interdisciplinary inquiry along the nature/society divide. The paper concludes that these “largely ignored” contributions offer urban ecology the opportunity to claim much broader depth as a field gaining access to precedents and innovations accomplished during the field’s early theoretical development. Drawing upon this history, a framework for ecological urban development is suggested to inform and assist contemporary research in urban ecology and planning.

Keywords Urban ecology · Interdisciplinary · Theory · Nature/society divide · Urban ecological development

Under-theorization in ecological urban development

Researchers describe urban ecology as a new interdisciplinary field whose integration of social and ecological science makes it “one of the busiest research intersections between social and biophysical processes” (Dow 2000). This position has attracted interest from a broad range of fields, publications and public and private funding sources (Young and Wolf 2006). Despite this attention, critics have portrayed the field as under-theorized, especially

R. F. Young (✉)
Department of Planning, Public Policy and Management, University of Oregon, Eugene, OR 97403, USA
e-mail: ryoung@uoregon.edu

in its nexus between ecological and social science, (McDonald and Patterson 2007; Pearce 2006; NSF 2002; Collins et al. 2000). Although urban ecologists have responded by examining ecosystem development within urban settings and incorporating human influence into analyses of urban ecosystems (Collins et al. 2000; Niemela 1999; Trepl 1995), syntheses relevant to patterns and processes of urban development have been inadequately addressed (McDonald and Patterson 2007).

Defining urban ecology as the interaction of social and ecological systems within urbanized space and the impact such interactions have on external systems, this paper examines obstacles cited in the literature as contributing to this under-theorization. Using demographic data to identify regions of initial acute urbanization, the paper then explores an interdisciplinary set of urban environmental critiques that emerged in regions of early urban dominance, drawing from them contributions useful to present day efforts in urban ecology and planning. In reviewing this history the paper explores whether urban ecology might claim greater historical and interdisciplinary depth.

Defining “urban”

Statistical

Researchers in urban ecology have refined the definition of the field from simply human dominated ecosystems to classifying urban environments through a broad range of social and ecological factors. Despite this refinement, urban ecology research has frequently lacked clear definition of what constitutes urban places, inhibiting the ability to replicate research for different locations or times (McIntyre et al. 2000). In response to this deficiency, McIntyre et al. (2000) advocate a definition of urban environment “explicitly including baseline information on demography, physical geography, socioeconomic, and cultural factors that can potentially explain existing urban structure and predict trajectories of growth.” (McIntyre et al. 2000, p 18).

Accepting this framework, this paper defines communities demographically as spatially specific concentrations of human settlement while allowing cultural interpretations of what constitutes “urban”. Assembling this demographic data required me to compare historical metropolitan populations and integrate data representing different spatial frameworks and varying reference dates, necessitating some extrapolation. In addition demographic sources used different definitions of what constituted urban agglomeration. In the studies I used to derive “percent urban”, the definition of urban populations ranged from minimum municipal thresholds of 2,500 to 10,000 persons (i.e. UN 2005; Klein 2004; Bacci 2000; Anderson 1996; Hohenberg and Lees 1995; Hauser et al. 1982; Weber 1976; Law 1967).

Although this range is not insignificant, it does not undermine derivations of the data. As noted, cultural perceptions of what is urban play a major role in defining both official figures and common experiences of what constitutes urbanized landscapes (UN 2005; Brabec 2001). National census figures are based upon the codification of these types of assumptions such that differing population figures may represent similar cultural and administrative perceptions of “percent urban”.

Historical

Defining “urban” faces a second issue: the city’s changing nature over time. During the past two centuries metropolitan areas have undergone unprecedented changes in population,

technology and design. Despite such transformations, cities are engaged in a constant double bind. As centers of productive consumption they have exceeded their internal capacity to supply themselves with goods and raw materials thus becoming sinks for energy and material sourced outside their borders. These inputs generate a further problem: managing and disposing solid, liquid and air-borne wastes in a footprint with limited absorption capacity. The result has been continuous exploitation of social and ecological systems to supply the inputs and disposal capacity necessary to support the city (Wackernagel et al. 1996; Odum and Odum 1976).

Critics have described this antagonistic relationship as a “metabolic rift”: increasing urban energy and material needs and absence of effective recycling of these inputs to the ecosystems supplying them resulting in conflict between the two systems (Moore 2000; Foster 1999). Although human settlements show evidence of such dislocation throughout history, the Industrial Revolution amplified its intensity (Hughes 1975; Hawken et al. 1999). While inputs and sinks have changed, the reliance of industrial systems upon increasing accumulation has insured continuing precedents in the requirements of the modern city. Thus critical thought in each successive phase of modern metropolitan development responds to urban systems of unprecedented scale and impact (McGurty 2003; Rosen 1993). The unity of this experience allows earlier theoretical inquiries examining the relationship between social and ecological systems to inform contemporary critical studies.

Under-theorization

Present-day critics have described urban ecology’s under-theorization as rooted in urbanization’s rapidly accelerating scale as well as historical biases influencing Western intellectual development. Specifically identified causes of under-theorization in urban ecology include:

- The unprecedented demographics of urbanization, i.e. recent attainment of a global urban majority (50%+urban population) and
- Bias in Western intellectual traditions failing to integrate nature and society

Researchers argue these factors have hindered the integration of social and ecological perspectives, obstructing meta-level analyses in urban ecology necessary to study human dominated ecosystems and develop sustainable urban systems (McDonald and Patterson 2007; Redman et al. 2004; Pickett et al. 1997; McDonnell et al. 1997; Rees 1997; Freudenburg et al. 1995).

Unprecedented urbanization

Negative impacts of rapid metropolitan growth on biodiversity, resource stocks, and human and ecological health are often noted as imperatives for urban ecology research (e.g. Hruska 2006; Marzluff 2005). Studies have identified unprecedented urbanization and human domination of global bio-geochemical cycles as challenging foundations of “normal science” (the disciplinary framework bounding acceptable research in a given field), prompting new investments in interdisciplinary urban ecology research, environmental studies, theory and design (UN Millennium Project 2005; Niemela 1999; Brennan 1999; Vitousek et al. 1997; Costanza et al. 1997).

The patchiness of urban growth

Describing the demographics of contemporary metropolitan growth, and its social and ecological effects as unprecedented places this discourse at a global level. While present-day urbanization is statistically unique (at no previous time has the human majority lived in cities), categorizing contemporary events as unprecedented, abstracted from heterogeneous, local, and historical context, eliminates opportunities to examine earlier responses to acute urbanization.¹

Patch dynamics, used in urban ecology to describe localized, heterogeneous mosaics of social and ecological change, offers an alternative framework to global discourse. It is based upon a concept of dynamic landscapes composed of habitat patches: distinct locations where species influence the concentration, flow, and generation of resources within landscapes. Patch dynamics describes transformations in patch structure, function, and composition that materially impact ecosystems as a whole. As a result, although distinct, patches are connected, influencing each other through factors such as migration (Pickett et al. 1997; Zipperer et al. 1997; Forman 1995).

Human dominated landscapes are equally subject to these dynamics processes (Frisbie and Kasarda 1988; Pickett, et al. 1997; Rebele 1994). Indeed, “[t]he annals of city, town, and community history are replete with changes that easily fit the definition of patch dynamics” (Pickett, et al. 1997, 192). Human migrations to metropolitan centers can be described in these terms. As an uneven, heterogeneous process, urbanization has materialized in different time frames and geographic scales creating multiple “patchy” spatial and temporal contexts within which acute urbanization and responses to it have emerged. Beneath global urbanization dynamics are continental, national, and regional “patches” of human settlement patterns that portray a more varied experience of metropolitan development. For example, Europe, less urban than Asia or the Middle East prior to the early nineteenth century, has led the recent global metropolitan surge, reaching an urban majority 67 years before the global population as a whole (1940 v. 2007) (Fig. 1):

England led the drive to urbanization in both the continental patch of Europe and the world, attaining its urban majority 89 years before Europe (1851 v. 1940) and 136 years before the world at large (1851 v. 2007) (Fig. 2):

At a finer grain, regional patches of acute urbanization reside within national patches. For example, the majority of the United States population was urban 87 years prior to the globe (1920 v. 2007) and 20 years before Europe (1920 v. 1940), however the Northeastern US reached an urban majority by 1881, only 30 years after England (Fig. 3).

Impact on resource stocks, human and ecological health

The rise of industrial metropolitan centers resulted in acute impacts on human and ecological health. By the 1850s English society became the first urban majority but accompanying its rise were urban driven pollution and disease causing increased mortality rates in some cities (Razzell and Spence 2005; Szerter and Woolcock 2004). Similar negative urban environmental influences left life expectancy in the largest urban departments of France up to a decade shorter than France as a whole until the latter half of the 1800s (Preston et al. 1978).

¹ ‘Acute urbanization’ is defined, for the purpose of this paper, as spatial formations whose human population exceeds 50% urban

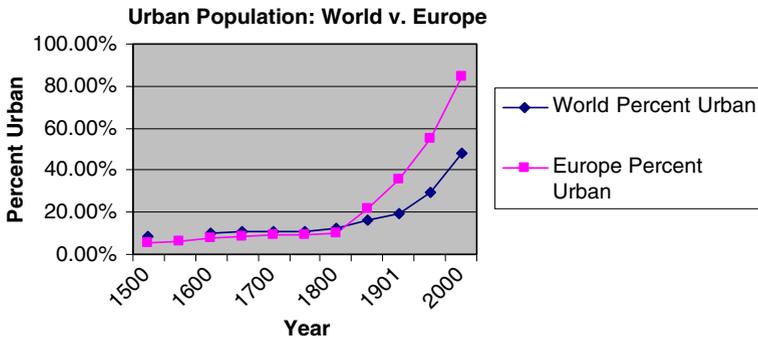


Fig. 1 Urban population: world v. Europe. Derived from UN 2006; Hohenberg and Lees 1995

It was not until the end of the nineteenth century that human death rates in cities in Western Europe and the United States fell below those of the countryside. Chronically improper sewage disposal in the cities, its effects on water quality and the subsequent spread of disease throughout dense urban populations made early cities centers of population loss (Vogele 1999; Institute of Historical Research Symposium 1992). This “urban penalty” was not fully eliminated until the first half of the twentieth century (Haines 2001).

Urban development also affected remote ecological patterns, bringing widespread resource pressure and ecological degradation more than a century in advance of contemporary environmental concerns (Brondizio et al. 2002; Browder 2002; Simmons et al. 2002a). For example, between 1830 and 1890, metropolitan demand for agricultural products and subsequent disruption of nutrient cycles through disposal rather than recycling of urban nitrogenous wastes (generally in neighboring water bodies) made depletion of natural soil fertility a dominant social and ecological problem. Concern over soil exhaustion led to significant new investments in research and resource exploitation to secure agricultural inputs resulting in further expansion of urban ecological footprints. Importation of naturally occurring organic fertilizers such as guano became a principal means to address this issue. Between 1841 and 1847, guano imports to England increased from 1,700 tons to 220,000 tons annually. The concurrent destruction of bird communities through such “strip mining” of guano became one of the many growing environmental impacts of urbanization (Foster 2002).

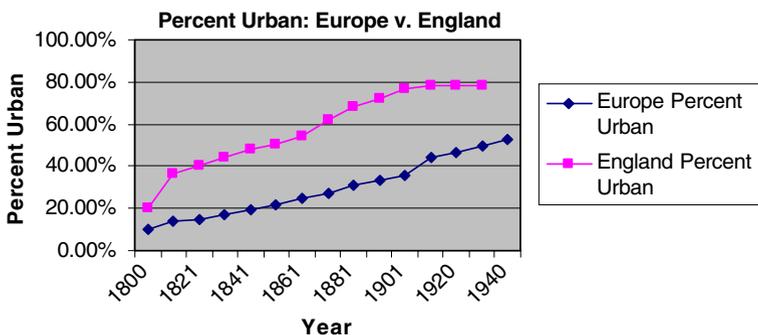


Fig. 2 Percent urban: Europe v. England. Derived from Bacci 2000; Anderson 1996; Law 1967

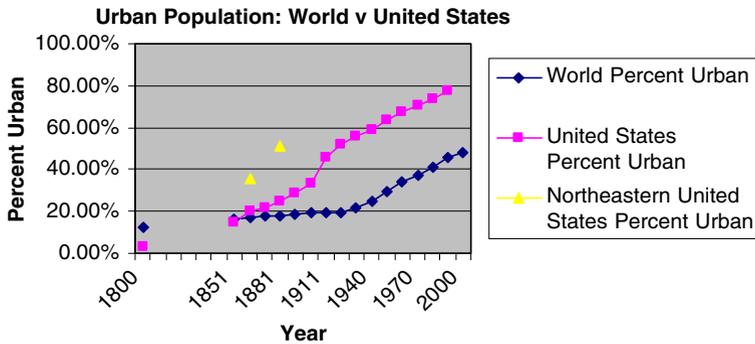


Fig. 3 Urban population; world v. United States. Derived from Klein 2004; Weber 1976; Hauser et al. 1982

Extracting metals to supply metropolitan growth had similar effects in the hinterlands. Extensive mining and smelting operations created acid rain, deforestation, and soil erosion radically altering local environments (Hodgson et al. 2000). In addition, deforestation to support the plantations and large-scale agriculture supplying urban centers altered regional climates around the globe, changing precipitation rates and affecting temperature regimes (Harmon and Marks 2002; Bonan 1999).

Theoretical underdevelopment of social and ecological integration

Despite historical metropolitan pressures on human and global ecosystem health, contemporary writers have criticized nineteenth century proto-ecological studies as ignoring human-dominated landscapes in favor of an ideal of wilderness. This bias is characterized as having contributed to conceptual separation of “man” and “environment” (Costanza et al. 1997; Wallbridge 1998; McDonnell and Pickett 1993). Departures from this bias are “more often ignored than used” (Botkin and Beveridge 1997, 3), “virtually unnoticed” by scientists and lay-persons alike contributing to a “perceptual gap”. This gap, critics argue, reflects “a deep cognitive bias of western industrial culture” privileging human social systems as exceptional in relation to ecological systems. “In short, western culture rarely recognizes urbanization and cities as manifestations of human ecology.” (Rees 1997, 63).

The product of this lack of recognition, researchers argue, is underdevelopment of theoretical tools to examine interrelationships between society and ecology (McDonald and Patterson 2007; Collins et al. 2000; Trepl 1995). Such tools, they suggest, could be made more effective through combining social and ecological studies into subsystems of a meta-analysis within the field of urban ecology (Pickett et al. 1997).

“Normal science” and the intellectual roots of urban ecology

This critique is not unprecedented in environmental studies. Early work in environmental sociology raised similar concerns, charging sociology with overlooking associations between society and ecology thus supporting division between humanity and nature (Dunlap et al. 2002). This critical position was itself brought into question by subsequent research illuminating the previous depth of work along the nature/society boundary by founders in the field of sociology (Foster 1999).

Thomas Kuhn anticipated such boundary questions in *The Structure of Scientific Revolutions* (1970). Kuhn proposed that crises in social relations and intellectual

perceptions often give rise to new scientific paradigms. During crises, the weakness of the dominant paradigm allows researchers legitimate access to wider spectrums of inquiry, only later the domains of distinct disciplines (Kuhn 1970). This initial period's interdisciplinary character allows multiple fields to claim its intellectual achievements; thus foundations can overlap in work later asserted the birthright of specific disciplines.

As a new dominant paradigm emerges, boundaries of “normal science” are reestablished providing productive but limiting frameworks around further work. In this transition “initial divergences...largely disappear...to a very considerable extent and then apparently once and for all”. This result “is usually caused by the triumph of one of the pre-paradigm schools, which, because of its own characteristic beliefs and preconceptions, emphasized only some special part” of the available research (Kuhn 1970, 17). This triumph is maintained until new contradictions become sufficiently acute as to make adherents lose faith and reengage in a broad, interdisciplinary search for new answers.

In the nineteenth and early twentieth centuries rising urbanization rates and impacts on resource stocks and human and ecological health generated such a crisis, prompting leading public intellectuals to investigate the relationship between metropolitan and ecological systems (Grove and Burch 1997; Botkin and Beveridge 1997; Brachi and Smith 1981). Subsequently, ideas developed in regions of early urban dominance may provide insight into theories of metropolitan development useful to present day urban ecology. This paper reviews contributions to this “largely ignored” history and explores whether urban ecology might claim broader historical interdisciplinary depth as a field, gaining access to the precedents and innovative work accomplished during this early period of theoretical exploration.

Methodology

I have chosen five iconic authors from this period for discussion in this article. Selection was based upon a combination of criterion and theory-based sampling. In criterion sampling, critical incidents can be a basis for selection (Patton 2002). I selected the period surrounding acute urbanization (+50% urban) as such a criterion. Within this temporal framework I selected spatial patches of emerging acute urbanization as potential areas for more in-depth analysis.

I identified three regions that fit the criterion, in this case northern Europe (London and Paris in the early-mid nineteenth century), the Atlantic northeast, and northern Great Lakes regions in the United States (the New York-Boston and greater Chicago conurbations in the late nineteenth and early twentieth century). I then used theory-based sampling to identify authors in these regions who were addressing the radically changing relationship between ecology (which they predominantly termed “nature”) and society.

In theory-based sampling, “[t]he researcher samples incidents, slices of life, time periods, or people on the basis of their potential manifestation or representation of important theoretical constructs” (Patton 2002, 238). This approach allows researchers “to select multiple operational representations of each construct, chosen because they overlap in representing the critical theoretical components of the construct” (Cook, Leviton, and Shadish 1985, 163–164 from Patton 2002, 239). For this paper, sampling was based upon the review of authors engaged, within the spatial and temporal frameworks noted above, in a critical approach to urbanization that legitimated urbanism while questioning the nature/society divide.

Although selecting single personalities can affect, as Kuhn noted, “the unfortunate simplification that tags an extended historical episode with a single and somewhat

arbitrarily chosen name” (Kuhn 1970, 15), urban ecologists have identified individuals and ideas as important factors in gaining a comprehensive view of urban ecology (May 2004; Odum 1971). In addition, these prominent individuals were part of a long, if limited tradition of research examining ecological aspects of human dominated landscapes (Sukopp 2002).

Unity of society and nature in theories of ecological urban development

As noted, critics have assailed a focus on wilderness in nineteenth and early twentieth century environmental research as encouraging intellectual separation of humanity and nature (Wallbridge 1997; Rees 1997).² While some early researchers did examine the botany of ruins and waste areas within cities, their explorations “looked for particular biotopes, for nature in a city, not for the nature of a city as a whole” (Sukopp 2002, 373). These early studies were mainly descriptive, comprised of botanical lists, terminology, and methods. Researchers such as the Swiss botanist Albert Thellung (1881–1928) made important contributions to urban ecology in this regard, however, this type of work was non-theoretical leaving the division between nature and society unexamined (Sukopp 2002).

However, rapid urbanization also created opportunities to critically address the nature/society divide. Some intellectuals reacted negatively to metropolitan ascendancy (White and White 1964). Others, although critical, were not anti-urbanists and embraced the city, seeing in urbanism opportunities to resolve such division.

The latter were more than “city boosters” interested in the speculative value of urban development or the promise of metropolitan centers as growth machines, seeing “unity” only in nature’s role as hand-maiden to a manifest destiny of continued urbanization. Rather they included a diverse range of public intellectuals drawn from a wide range of countries and disciplines who were engaged in exploring the synergy between ecological and social systems. Counted among them were prominent figures such as German scientist and polymath Alexander von Humboldt, American landscape architect Fredrick Law Olmsted, English town and city planner Ebenezer Howard, Scottish evolutionary biologist and regional planner Patrick Geddes, and American sociologist Robert Ezra Park.

Alexander von Humboldt

Alexander von Humboldt (1769–1859), perhaps the most well-known and regarded scientist of his period, exerted extensive influence on environmental science and the humanities (Sachs 2006). Humboldt spent the majority of his life in Paris and Berlin during their rise as global metropolitan centers and conducted field investigations in the hinterlands and cities of Europe and Central and South America. During his work in France, Paris rapidly urbanized becoming the second largest metropolitan center in northern Europe. Such concentrated growth, overlapping in part with the reign of Napoleon’s empire and the financial, intellectual and artistic wealth it gathered, laid the groundwork for Paris to become the “capital of modernity” (Harvey 2005). In this context, Humboldt, a pioneer

² This criticism falls within the greater critique of modernity that posits a decontextualized, reductionist approach to knowledge creation (Latour’s “modern constitution”) with disenchantment of the world, supporting the emergence of a conceptual division between nature and society (Latour 1993)

in the fields of ecology, geology, climatology, political economy and anthropology, “officiated at the birth of modern science and helped lay the foundations upon which our modern world is built” (Gendron 1961, 14).

Unity of society and nature

As the core of this foundation, Humboldt argued, “the most important aim of all physical science is this: to recognize unity in diversity” (Gendron 1961, 177). Humboldt’s work reflected this goal: joining social and ecological systems in his studies on the natural sciences as well as urban geography, political economy and anthropology. He brought together these perspectives to identify the role of ecology in the development of human agriculture, settlements and consciousness as well as their effect in turn on the configuration and comprehension of ecology (Humboldt 1969, 1966, 1880). Ecology and society were parts of a seamless continuum that radiated, Humboldt argued, throughout the entire cosmos. To Humboldt, scientific inquiry unveiled laws governing this unity and should painstakingly reveal these connections.

Theory: Energy as the basis for society and ecology

Identifying relationships between society and ecology enabled Humboldt to gain early theoretical insights applicable to both. In particular, Humboldt observed how energy shaped social and ecological systems. While engaged in fieldwork in the Andes, he made significant contributions to plant geography by noting the effect physical factors had in the distribution of plant communities. In addition, he calculated, from existing ruins, the historical population of Incan cities and based upon these estimates and the proportion of arable land in the vicinity approximated the level of social and ecological inputs necessary to support the Incan Empire’s urban networks. In stark contrast to previous research drawing little connection between ecology and urban infrastructure, Humboldt noted, “an accurate knowledge of the origin of the [urban] arts can be acquired only from studying the nature of the site where they arose (Humboldt 1814).

Humboldt understood the energetic underpinnings of human and ecological communities to be integral. The physical unity between social and ecological systems reflected the ultimate unity of the Cosmos which included humans and nature: “I have been constrained to admit while ranging the Amazon forest or scaling the heights of the Andes”, he wrote, “that there is but One Spirit animating the whole of nature from pole to pole - but One Life infused into stones, plants, animals, and even into man himself” (Humboldt 1850).

Humboldt’s comprehension of ecological and social co-creation and early understanding of energy as an underlying force joining them preceded by two centuries contemporary work in urban ecology exploring energy’s central role in shaping social and ecological systems (Simmons et al. 2002b; Sorrenson 2002; Decker et al. 2000; de Wet, et al. 1998; Loeb 1998; Pickett, et al. 1997; Odum and Odum 1976; Odum 1971).

Frederick Law Olmsted

Frederick Olmsted (1822–1903) is credited as a founder of the field of Landscape Architecture (Mann 1993). Witness to the rapid emergence of the northeastern United States’ urban majority and concerned about its impact on culture and human health, Olmsted addressed this tension through the integration of urban design and nature.

Unity of society and nature

Creator of 17 major urban parks as well as parkways, planned garden communities, individual estates and elements of the State and national park system, Olmsted also wrote numerous books, reports and essays on urban theory, horticulture and park and urban design, joining together cultural and ecological aspects in the landscapes he analyzed and envisioned.

Olmsted rejected ideas that he designed urban gardens isolated from society and environment. In a report on the Chicago Columbian Exposition of 1893, requested by the American Institute of Architects, he stated: “[I]t may be observed that the word garden comes to us from the same root with girdle, girth, garth and others to be found in every European tongue, all of which imply something limited, restrained and separated from what exists beyond or about it, or that is the cause of such limitation, restriction or separation.” Rather, Olmsted was clear that an inclusive analysis was necessary. Although the word ‘garden’, he stated “implies reference to a limited, defined and exclusive place” the term ‘landscape’ through which Olmsted viewed his work, “is so comprehensive that it may take in houses, lawns, gardens, orchards, meadows, mountains and even the sky” (Olmsted 1893 cited in Sutton 1971, 181).

Theory: Growth

Although critical of mass urbanization’s effects, Olmsted remained a booster of large-scale urban and economic growth (Beveridge and Schuyler 1983). While declaring a city’s economic expansion a necessary precursor to social and cultural development, Olmsted pressed for green space as a fundamental part of metropolitan infrastructure: “We are bound...to look upon the park to be formed on your site simply as one member of a general system of provisions upon which as a whole the health of the city, its attractiveness as a residence and its prosperity will in all future time be largely dependent”, Olmsted and his partner Calvert Vaux explained to the park commissioners of Chicago (Olmsted and Vaux 1871 cited in Sutton 1971, 159). Olmsted believed open space fundamental in determining the shape of a city’s future expansion. “The whole scheme of improvements should, as far as possible, therefore, be definitely established at the outset, and the plan of the city in all respects adjusted to suit it” (Olmsted 1866 cited in Sutton 1971, 120).

Urban green space was a keystone of successful metropolitan growth: “It should be well thought of”, he instructed the commissioners of the City of Buffalo, “that a Park exercises a very different and much greater influence upon the progress of a city in its general structure than any other ordinary public work...” (Olmsted 1869, 12.). Its influence stemmed from its counter balance to capital accumulation. The collateral social and environmental damage generated by commercial activity in cities, Olmsted argued, made urban citizens physically and psychologically unhealthy, undermining economic gains. Fusing nature into urban development was the means to offset such damage.

The result, Olmsted asserted, would unite humans and their environment through what he termed “unconscious” or “indirect recreation” which “employs the mind without fatigue and yet exercises it, tranquilizes it and yet enlivens it; and thus through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system” (Olmsted 1869 cited in Rybczynski, 1999, 258). To Olmsted, unity between nature and urban dwellers was not only physical but created mental and spiritual union: “Gradually and silently the charm comes over us; the beauty has entered our souls; we

know not exactly when or how, but going away we remember it with a tender, subdued, filial-like joy” (Beveridge and Schuyler 1983, 22).

Olmsted’s identification of urban green space as a necessary component of metropolitan development anticipated by a century and a half contemporary urban ecology research investigating the role of open space in the growth of urban ecosystems (Benedict and McMahon 2006; May 2004; Haeuber 1999; Towne 1998; Pickett 1997; Pouyat 1997). His discussion of the psychological benefits of open space further anticipated forays by urban ecologists examining connections between ecology, the urban environment and human mental well-being (Hunter 2001; Schellekens 1979; Rapoport 1978).

Ebenezer Howard

Historians have identified Ebenezer Howard (1850–1928) as a pioneer of modern city planning (Mumford 1965). A witness to the inauguration of the “age of cities”, Howard resided in London during the decades in which large metropolitan centers became dominant in British society. Like Olmsted, he saw great opportunity in cities but was appalled at their collateral effects on human and environmental health. Principally engaged in the establishment of two garden cities in England (Letchworth and Welwyn), Howard was author of the influential *Garden Cities of To-Morrow* (Howard, 1965) and founder of the international garden cities movement.

Unity of society and nature

Howard proposed the garden city idea: unifying “town and country” in new and revitalized communities, as a central path toward resolving the mounting antagonisms of rapid urban growth; a garden city was to be set in nature as much as infused by nature throughout (Osborn 1965). Reintegrating these elements, Howard argued, would overcome the dichotomies of modern urbanization. The garden city, guided by the best available social and environmental science, would erase the division between society and nature: “Human society and the beauty of nature are meant to be enjoyed together. The two...must be made one. As man and woman by their varied gifts and faculties supplement each other, so should town and country” (Howard 1898 (1965), 48).

Howard identified nature, or “country” as the inseparable basis of physical and aesthetic expression in human society. “All that we are and all that we have comes from it. Our bodies are formed of it: to it they return. We are fed by it, clothed by it, and by it we are warmed and sheltered. On its bosom we rest. Its beauty is the inspiration of art, of music, of poetry. Its forces propel the wheels of industry. It is the source of all health, all wealth, all knowledge. But its fullness of joy and wisdom has not revealed itself to man. Nor can it ever, so long as this unholy, unnatural separation of society and nature endures. Town and country *must be married*, and out of this joyous union will spring a new hope, a new life, a new civilization” (Howard 1898 (1965), 48).

Theory: Garden city dialectics

Critics have characterized Howard’s effort to reintegrate ecology and society as theoretically lacking (Clavel 2002; Beevers 1988). However Howard’s garden city proposal outlines a classical dialectical approach. Dialectics, as articulated by Aristotle and Hegel, propose change as driven by internal contradictions inherent in all things. Although Howard described Earth “as abiding forever” he was cognizant of the ubiquitous nature of change it

embodied. Social systems such as cities and economies were in constant transformation as was nature. Just as individual physiognomy unfolded toward realizing its possibilities, so too could communities. The driver of this process was, for Howard as for Hegel, an organic process of “becoming” (Howard 1898 (1965); Hegel 1969).

“A town,” Howard noted in *Garden Cities of To-Morrow*, “like a flower, or a tree, or an animal, should, at each stage of its growth, possess unity, symmetry, completeness, and the effect of growth should never be to destroy that unity, but to give it greater purpose, nor to mar that symmetry, but to make it more symmetrical; while the completeness of the early structure should be merged in the yet greater completeness of the later development” (Howard 1898 (1965), 72). Such symmetry did not reflect static harmony. Rather it described the symmetry of forces that drove organic forms toward “greater purpose” and “completeness”, toward higher levels of dialectical interaction.

Howard graphically represented the tensions inherent within and between the environment and urban form in *Garden Cities of To-Morrow*. The “town”, as Howard referred to urban centers, “closed out nature” while offering both social opportunities and distress. The “country”, as Howard described less human-dominated settings, contained the “beauty of nature” but remained incomplete in its “lack of society” and poorly compensated labor (Howard 1898 (1965), 48). To Howard, these contradictions were unnatural and “unholy”. Neither the town nor the country could achieve a higher form of “becoming” while ecology and society excluded each other.

The garden city represented the resolution of these contradictions, a new stage of symmetry where fresh contradictions would elaborate further levels of becoming. The garden city, wrote Howard, “is indeed a *Master Key*, for it is the key to a portal through which, even when scarce ajar, will be seen to pour a flood of light on the problems of intemperance, of excessive toil, of restless anxiety, of grinding poverty...ay, and even the relations of man to the Supreme Power (Howard 1898 (1965), 44). Once established, it illuminated opportunities through civic engagement and scientific and spiritual exploration to realize higher unities between humanity and the environment.

In acknowledging the co-creative force of society and ecology, Howard anticipated by a century contemporary urban ecologists and planners exploring green infrastructure, ecosystem services, industrial ecology and, more broadly, the nature/society divide (Benedict and McMahon 2006; Botkin and Beveridge 1997; Rees 1997; Freudenburg et al. 1995). Howard celebrated cities, rural landscapes and non-human nature. By contextualizing their internal contradictions and evolution through a dialectical process, Howard’s work also presaged contemporary writings in dialectical urbanism and biology (Merrifield 2002; Levins and Lewontin 1985).

Patrick Geddes

Patrick Geddes (1854–1932), an accomplished biologist, botanist and sociologist, is most prominently identified as one of the founders of modern regional planning (University of Dundee 2007). A contemporary of Ebenezer Howard’s, Geddes also witnessed the explosive expansion of cities and focused his work on addressing social and environmental problems generated by their unprecedented growth and dominance.

Unity of nature and society

To Geddes, integrating cities with the past and future potential of their regional ecology was central to ameliorating their problems. Vital to this process was understanding how a city’s

social and ecological history laid the groundwork for its present and future prospects. As Geddes noted, anticipating by nearly a century efforts in urban ecology research such as the National Science Foundation's Long-Term Ecological Research projects in Baltimore and Phoenix: "A city, in sum, is a natural and social palimpsest where one may read, in half-effaced, overlapping, yet unmistakable symbols, the true records of history" (Redman et al. 2004; Geddes 1910 cited in Boardman 1944, 335).

Geddes argued that human culture, productive activity and ecosystems were all joined in a process of mutual modification and creation he described as "Folk, Work, Place". As society developed, local ecology and human endeavor engaged and differentiated to produce modern metropolitan regions. These regions, Geddes offered, could be regenerated by understanding connections between their social and ecological forces: "Such regeneration is not merely nor ultimately geographical alone: it is human and social also", he noted (Geddes 1915, 159).

Theory: Cities in evolution

Drawing from his training in biology, Geddes proposed an evolutionary theory of development that applied to both ecology and the city. An enthusiastic supporter of Darwin, Geddes used evolution as a theoretical template through which to describe potential paths of urban form and function (Geddes 1915).

Geddes saw cities as organisms that, like their biological counterparts, could fail as well as evolve. Geddes labeled industrial cities primitive "paleotechnic" conurbations, characterized by exploitation of human labor and non-renewable, polluting energy sources to drive fundamentally extractive economies. If unchanged, they would evolve, Geddes posited, from "polis" to "metropolis" to "necropolis" resulting in the death of culture, civilization and nature (Clavel 2002).

Alternately, paleotechnic cities had the opportunity to evolve toward what Geddes termed neotechnic society. Neotechnics distinguished greater cooperation and civic, institutional and ecological integration while embracing renewable energies, culture and regional ecosystems to support a fundamentally regenerative economy (Geddes 1915). Paleotechnic's disregard for life, both social and ecological made it an evolutionary dead-end for humanity and the rest of nature. Neotechnics, he countered, with its focus on life and retaining viable cultural elements from the past offered the opportunity for city-regions to pass from polis to metropolis to biopolis: the city of life (Welter 2002).

Geddes's work in regional surveys, ecological restoration, urban redevelopment and design reflected his position that urban evolution should be driven through practical realization of the city-region's inherent unity with its ecology: "My ambition being...to write in reality – here with flower and tree, and elsewhere with house and city – it is all the same" (Geddes cited in Welter 2002, 18). Thus he explored a path nearly a century in advance of present day urban ecologists and planners grappling with regional social and ecological integration and restoration (Fouda 2001; Solecki et al. 1999; Foresman et al. 1997; Embacher 1966).

Robert Park and the Chicago School

Robert Park (1864–1944) was a principal member of the first Chicago School (also referred to as the Ecological School) centered in the University of Chicago sociology department. Park's Chicago was the second largest and fastest growing city in the United States, increasing its population over 100 fold (30,000 to 3,400,000) during his lifetime. Over this period the United States joined England in achieving an urban majority.

Unity of society and nature

Working amidst rapid and decisive urbanization, Park and colleagues such as Ernest Burgess saw opportunities to interpret social development through ecological patterns and processes: “Man and society present themselves in double aspect” they wrote. “They are at the same time products of nature and of human artifice...Society is a product of both nature and design, of instinct and reason” (Matthews 1977, 137).

Park noted Frank E. Clements’ pioneering work in ecology, “might serve well as a model for similar studies in human ecology” (Matthews 1977, 138). In “Human Ecology” published in the *American Journal of Sociology* (1936) Park described this approach as “an attempt to apply to the interrelations of human beings a type of analysis previously applied to the interrelations of plants and animals” (Park 1936, 1). In an *American Sociological Review* article titled “Succession, an Ecological Concept” Park noted: “The same biotic interdependence of individuals and species, which has been observed and studied in plant and animal communities, seems to exist likewise on the human level...In short, human society is, or appears to be, organized on two levels, the biotic and the cultural” (Park 1952, 227). The modern metropolis, “like the peasant’s hut” he asserted, quoting Oswald Spengler, “has its roots in the soil” (Park et al. 1925, 1).

Theory: Succession

Drawing from Clements, Park proposed a theory of urban succession to describe patterns of change in the urban landscape. To Park, competition shaped the trajectory of succession in both ecological and social systems: “the principle involved”, Park noted, “seems to be substantially the same. In any case, all or most of the fundamental processes seem to be functionally related and dependent upon competition” (Park 1925, 10).

Although inspired by Clements’ work, Park, like ecologist Henry Gleason, critiqued its more rigid and deterministic elements. Park saw change in social systems as more complicated and unlike Clements, Park thought the chances of achieving climax communities negligible. Rather, Park argued in favor of a process of change akin to disturbance and punctuated equilibrium where the “balance of nature” (and social harmony) existed only in theory: “Every now and then something occurs, however, to disturb the biotic balance and social equilibrium, thus tending to undermine the existing social order. It may be the advent of a new insect pest, like the boll weevil, or the arrival of a newly invented and perfect artifact, like the automobile. Under these circumstances, forces and tendencies formerly held in check are released, and a period of intense activity and rapid change ensue which then continues until the cycle is completed and a new biotic and social equilibrium is achieved” (Park 1952, 229).

Park understood disturbance created opportunities for new social and ecological communities but these new configurations would themselves eventually change: “the equilibrium achieved will only be temporary or partial, and the termination of one sequence invariably becomes the starting-point for a new and different one. For society is like a plant or any other living thing, a moving rather than a stable equilibrium. Always it is involved in the process of becoming; always it exhibits something that corresponds to what is here called ‘succession,’ and ‘succession,’ as the ecologists have used the term, seems to include at once the processes of development and evolution” (Park 1952, 235).

Park and his colleagues’ intertwining of ecology and sociology preceded present efforts by urban ecologists to similarly enrich interpretations and understanding of urban dynamics (Miles et al. 1998; Grove and Burch 1997). The Chicago School’s comprehension of the

city's social systems shaped, in part, by ecological imperatives grasped a fundamental tenet of contemporary urban ecology research. Although Park and his colleagues were subsequently criticized as incorporating elements of determinism in their analysis and Fredric Clements' rigid ecological sequences were replaced by the contingent frameworks presented by Gleason and Whittaker, the Chicago School's postulation of shared, stochastic influence between ecological and social systems was radical in its day preceding by nearly three quarters of a century present efforts in urban ecology to explore these connections.

Developing an analytical framework for ecological urban development

Redman, et al. comment that “[i]t is no longer tenable to study ecological and social systems in isolation from one another,” citing an “urgent need to construct new approaches that emphasize an integrative framework equipped with comprehensive models” (Redman et al. 2004, page 161). Mazoyer and Roudart provide such scope in their history of agriculture, identifying human-dominated systems as complex ecological and economic objects where “over time...in a given region of the world different species of agriculture can succeed one another, forming stages of an ‘evolutionary series’ characteristic of the history of this region”. They propose this framework for agrarian systems “precisely as an intellectual tool enabling one to apprehend complexity and construct a general outline of the historical transformations and geographical diversity of the world’s agricultural systems” (Mazoyer and Roudart 2006, 21–22).

Metropolitan centers, like agricultural systems with which they are integrated, are also human-dominated, complex, adaptive, economic and ecological systems (Madanipour et al. 2001). By drawing upon the theoretical work of Olmsted, Howard, Park, Humboldt, and Geddes an “evolutionary series” can be constructed to explore urban development making it, as Mazoyer and Roudart (2006) assert in their work on the history of agriculture, “possible to represent the continual transformations...in a region of the world as a succession of distinct systems, forming a definite historical series”. Though not deterministic or necessarily linear, such series provide analytical frameworks that extend beyond metaphor “to apprehend and explain in broad outlines the geographical diversity of [such systems] in a given epoch” (Mazoyer and Roudart 2006, 51; Norgaard 1994). This process for metropolitan regions is identified in this paper as ecological urban development.

Trajectory and place

Ecological urban development can be described as a series of dynamic positions through which internal and external drivers exert influence. Analyzing these drivers and dynamics can help locate a metropolitan region's position in the series and illuminate potential future development directions and tensions.

The initial position in the series is growth. Both ecological and socioeconomic systems are described as capable of growth but they are often accounted for in the literature separately (i.e. economic expansion v. biological growth). This binary perspective, advanced by Olmsted and contemporary advocates of “green infrastructure” (i.e. parks, street trees, greenways, nature preserves, etc.), conceptualizes social and ecological systems as complementary (Benedict and McMahon 2006; Olmsted 1983). Although these and other writers describe them in terms of mutual counterbalance, the requisite internal dynamics of capital accumulation and ecological development remain at odds, generating significant tensions (Foster 2007).

These tensions, both internal and external, generate a second dynamic position: dialectics. The dialectical process applies to ecological and social systems both in terms of social struggles and ecological change where contradictory relationships within and between individuals influence and are influenced by the environment within which these transformations take place (Merrifield 2002; Levins and Lewontin 1985). The necessity for capital accumulation to expand brings it into conflict with social and ecological development. The dialectical dynamic of these forces creates formative pressures (“becoming” as described by Hegel and Howard) driving the series toward succession.

Succession, the unfolding of competitive relations in determining the character of social and ecological formations subject to stochastic influences in a particular place and time, has been used in research to interpret both social and ecological systems (Freeman 2005; Whittaker 1975; Gleason 1927; Clements 1916). Driven by competition, succession provides context to dialectical conflicts between individuals, their greater community, and place. The fitness or competitive advantage of individuals is defined in these struggles through interactions between a location’s constituent elements and environment (Kauffman 1993). In this context, the success of individual efforts in a particular place and time are framed largely by the fourth dynamic in the series: energy.

At the heart of the competitive process of succession lies the question of energy manipulation. In succession, individuals and communities who harness potential energy most effectively gain competitive advantage (Odum and Barrett 2005; Odum and Odum 1976). Individuals and communities that best utilize social and ecological energy flows are able to out-compete other individuals and communities to successfully colonize and even become dominant factors in spatial organization. Ability to effectively accomplish this manipulation, either independently or symbiotically, lays the groundwork for the fifth position: evolutionary success.

The framework of evolution has also been used to describe social and ecological systems (Gould 2002; Kropotkin 1955; Geddes 1915). Evolutionary success within these perspectives is not deterministic in terms of any normative idea of progress. Rather its definition resides in the objective ability of individuals and communities to succeed (survive and reproduce themselves) within the competitive pressures of succession framed by a particular location over time.

Concrete analysis

Ecological urban development is not an abstract formula that replaces examining the dynamics of particular ecological urban systems. It also does not offer a deterministic prescription of their eventual forms. Such particularities and forms can only be comprehended through concrete observation and analysis. An evolutionary series “offers a method and...system of reference, but certainly not a preconceived knowledge of reality that can act as a substitute for observation and analysis. The theory is not dogma” (Mazoyer and Roudart 2006, 52). Rather it offers a means to investigate the status and trajectory of ecological urban systems in a particular time and place.

Applying the framework of ecological urban development in this manner supports symmetrical, place-based investigations of the types of growth, tension, conflict, development, and evolution occurring within and between the ecological and social system and its subsystems present in urbanized space. Issues such as social and ecological resource flows and allocation, technology and infrastructure emergence and impact, policy changes, competition, and the introduction of new actors can be given context for analysis.

Conclusion

Urban ecology acknowledges that myths and ideas influence perceptions of the city and therefore “must leave room for intellectual and artistic drivers that transcend typical social/scientific categories” (May 2004, 8). During the nineteenth and early twentieth centuries different ideas vied to interpret the challenges and opportunities created by the rising dominance of cities. In the intellectual ferment of that period, within which modern disciplines of natural history, ecology, city and regional planning, landscape architecture and sociology were emerging, divergent voices sought to construct a coherent paradigm in the perceptions and theories that underlay the study of ecology and society.

Influential intellectuals such as von Humboldt, Olmsted, Howard, Geddes and Park sought to explore from various vantage points both concrete strategies for resolving the negative impacts of urbanization, and a view unifying social and ecological systems. Taken together they represent an interdisciplinary tradition resonant with later tenets of urban ecology. Rather than driving a wedge between “society” and “nature” and laying the groundwork for separation, their work provides a history of intellectual engagement which, like present day urban ecology, chose the city as a legitimate, positive focal point to unify social and ecological systems and practically and theoretically address urban environmental questions (Welter 2002; Hall and Ward 1998; Botkin and Beveridge 1997; Grove and Burch 1997).

Although these perspectives did not overcome dominant narratives of modernity in describing the rapidly changing relationship between cities and ecology, their lack of hegemonic success and subsequent relative obscurity does not alter the fact that they are firmly rooted in the Western intellectual tradition. Disappearance of alternate perspectives on the “nature/society divide” developed during the early triumph of urbanization can be seen as having more to do with consolidation of particular compositions of “normal science” in ecology and urban studies than an absolute bias at the heart of Western thought.

Although edged out of the framework of “normal science” these perspectives have remained nascent. Now new, global thresholds of crisis in the sustainability of the relationship between social and ecological systems are bringing into question reigning interpretations of the boundary between cities and nature. As a result this historical set of alternative viewpoints appears well positioned to contribute to efforts to formulate new, integrative paradigms. Urban ecology should claim this rich legacy of work as its own and put it to use in creating new analytical tools for research.

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