

Goal attainment in urban ecology research: A bibliometric review 1975–2004

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Abstract We analyze a core literature of urban ecology (all articles published in *Urban Ecology* and *Urban Ecosystems* from 1975–2004, $n = 261$) to support a reflexive analysis of the field. We structure this critical analysis based on criteria derived from programmatic statements made by scientific societies, research funding organizations and academic institutions regarding what urban ecology should be. Specifically, we assess the extent to which the literature reflects, and has evolved to reflect, a commitment to

- strengthen and expand the discipline of ecology
- create a transdisciplinary enterprise, and
- contribute to social and ecological wellbeing through applied research and policy engagement.

Findings indicate that the literature strongly reflects these commitments, as these three tenets usefully describe the field and its evolution. We do, however, identify a tendency over time toward a more strictly disciplinary orientation. Ecological science is increasingly dominant and threatens to crowd out other scientific perspectives. This trend suggests that the field is maturing in the institutional sense, but perhaps at the cost of intellectual diversity, which many believe to be the basis of innovative solutions.

Keywords Urban ecology · Bibliometry · Reflexive assessment · History of science · Governance · Interdisciplinary · Transdisciplinary · Policy engagement

Introduction

Cities are clearly implicated in the contemporary sustainability crisis. The unparalleled urbanization of the past century represents the largest human migration in history (Porter, 2001).

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These growing urban agglomerations are frequently located in fragile ecosystems (UN, 2000). As the now dominant form of human settlement, cities are a significant source of negative environmental impact, both directly through ecological disruption and indirectly through demand for and consumption of essentially non-renewable resources (Rees, 1996). As Cronon (1991) has demonstrated, growth of cities and their interactions with hinterlands produce environmental change at both local and regional scales. Given the expanding ecological footprint of urban areas, there is a growing sense that solutions to the world's dominant social and ecological challenges will primarily be met within an urban and regional framework.

Recognition of cities as environmentally significant, rather than places in which separation from nature (i.e., modernity) has been most nearly realized, has given rise to a science of urban ecosystems (Pickett, 1997). While ecological analysis of human-dominated ecosystems has been described as a relatively new scientific activity (Collins, 2000), the field has given rise to a growing portfolio of research including dedicated journals, local and international conferences, foundation support and federal initiatives. As a fusion of social science and ecology, urban ecology exists “on one of the busiest research intersections between social and biophysical processes” (Dow, 2000).

While development of scientific understanding of urban ecology can be seen as a necessary response to the social problems and scientific questions raised by contemporary patterns of urbanization, not much is known about the practice and products of urban ecological science. Various arguments suggest that it would be naive to assume that scientific output can be predicted solely through consideration of the social context in which the science is practiced. As a new area of investigation, it is reasonable to expect that practitioners hold diverse understandings of the problems and practices that define the field (i.e., Kuhn's (1970) “normal science” would not yet be established). It is also reasonable to suspect that established professional and scientific fields would engage in what sociologists of science call boundary work (Frickel, 2004) or what is referred to more commonly as guarding one's turf.

Conflict over resources (e.g., money, status, claims to legitimate knowledge) could lead to urban ecologists fighting rear guard actions, rather than advancing their mission. Furthermore, practical matters such as unwillingness of funding agencies to invest in non-traditional projects, conservatism of peer review processes and tenure and promotion procedures, and unavailability of trained students and workers could constrain innovation. These challenges suggest that awareness of a need for new knowledge does not automatically translate into relevant scientific output. In the context of such constraints, we believe it is worthwhile to evaluate urban ecological science empirically.

The goal of this paper is to examine the field of urban ecology systematically and critically through an assessment of the scientific literature. In line with Fazey et al.'s (2005) empirical assessment of the field of conservation biology, we analyze correspondence between the scientific literature and programmatic statements regarding the objectives and practices of the field (i.e., normative or prescriptive judgments). The analysis allows us to evaluate the extent to which achievements match pronouncements. Further, we assess whether the literature has evolved over time so as to become more closely aligned with these commitments. We engage in critical reflection in order to identify both existing strengths on which to build and areas of unfulfilled promise. We hope that this reflexive assessment will be useful in guiding research, training students and recruiting new partners.

Objectives of urban ecology

Fazey et al. (2005) structured their assessment of the field of conservation biology through reference to a programmatic statement of what the field ought to be, as outlined in an article

by M. Soule. Soule is an ecologist long known for philosophically oriented reflection on scientific and educational practice in ecology. While we were unable to identify a strictly analogous programmatic statement, the Institute for Ecosystem Studies (IES, 2005), a globally significant center of ecological research, has publicly articulated what they consider to be “the three central questions” of urban ecology: i) how do urban ecosystems operate; ii) how are they affected by drivers from a wide range of disciplines; iii) how can this knowledge be used to address contemporary urban and environmental problems.

We interpret the first of these questions as a challenge to extend theories and tools of ecology for application in urban settings. The second question speaks to the need to engage multiple intellectual traditions and perspectives. The third question exhorts research scientists in urban ecology to engage in applied research and policy-relevant work. Drawing on pronouncements of professional societies, themes of scientific conferences, and funded research and education programs, we reflect on each of these programmatic commitments below.

Core commitments of urban ecology

Urban ecology's relationship with the field of ecology

Ecology, as a scientific discipline and an organizational network, has moved to recognize the relevance of urban places and urban processes. For example, in 1998 the Ecological Society of America's (ESA) annual meeting featured workshops and symposia announcing “The New Urban Focus” and “Urban Ecological Systems: A New Frontier.” More recently ESA identified the theme of their 2004 annual conference as “Ecological Explorations of Inhabited Areas.”

The National Science Foundation expanded the long-term ecological research (LTER) network by adding two urban locations in 1997 (Baltimore and Phoenix). Stewart Pickett, Director of the Baltimore LTER project, has noted that “[t]he knowledge gained from working on that [urban ecology] frontier will strengthen the field of ecology” (NSF, 1997). Outside the U.S., the United Kingdom's Natural Environmental Research Council has identified an opportunity to expand the field of ecology through urban ecology research.

Such resource commitments and programmatic statements should be evaluated in the context of an historical bias in the field of ecology against human dominated areas. A literature review drawing on nine leading ecology journals between 1993 and 1997 found that only 25 out of 6,157 published papers (0.4%) examined cities or urban species (Collins et al., 2000). This bias, and the resulting paucity of data and research, is a recurring theme in the urban ecology literature (McDonnell, 1997).

While lack of consensus as to what defines fundamental terms such as urban and urban ecosystem is regarded as a problem (Mcintyre, 2000), exploration of this new frontier is seen to be an opportunity to broaden the field of ecology. Recognition that human activity is an overarching driver of environmental change across a range of scales (e.g., Berkes and Folke, 1998) appears to have created an openness in ecology and willingness to engage the urban frontier. Because large-scale ecological processes are increasingly influenced by human activity, urban ecosystems are seen as potentially useful models for studying global ecosystem interactions and strengthening theories, methods and empirical knowledge (Mcintyre et al., 2000). Given these signs of openness, we seek to evaluate the extent to which the scientific practice of urban ecology consists of urban applications of ecological science.

Urban ecology as a transdisciplinary enterprise

Urban ecology both aspires and perceives itself to be a transdisciplinary project. As Scott Collins, NSF Director for the long-term ecological research program has stated “[f]actors that control urban ecosystems are not only environmental, but also social and economic.” As human dominated spaces in which engineering and social organization serve to mask ecological variation, environmental change in cities is a social process. But the environment is neither frictionless nor impotent. As a result, understanding the relevant feedbacks between social and natural systems will require sustained interaction among ecologists and a wide range of scientific disciplines including history, sociology, economics, public policy, engineering and public health.

Musacchio and Wu’s (2004) recent assessment of the state of the art of urban ecology emphasized the need for an interdisciplinary approach and hinted at the constraints that must be overcome to achieve this vision. “New research initiatives in urban and regional ecology in the United States represent an unprecedented opportunity for a broader dialogue between ecologists, social scientists, planners, and designers about the future of cities world wide. . . In order to address this challenge, ecologists, social scientists, planners, and designers will need to work collaboratively to develop interdisciplinary approaches for understanding the effects of long-term changes in urban spatial patterns, landscapes, and environmental quality.”

The American Association for the Advancement of Science highlighted the need for a transdisciplinary approach to the assessment and mitigation of environmental problems in urban space at their 1999 winter conference, “The Metropolis in the Millenium: Integrated Science and Urban Ecosystems.” The 2004 Ecological Society of America annual conference symposia, “Ecological Exploration of Inhabited Places,” explicitly addressed the need to integrate demographic, socioeconomic and ecological perspectives. Students of urban ecology at the University of Washington participate in a class entitled “Urban ecology and interdisciplinary perspectives” and the Baltimore LTER team has identified one of their objectives to be “building a bridge between the natural and the social sciences.”

Rather than focus narrowly on the questions of multidisciplinary (i.e., involvement of practitioners from a variety of scientific disciplines) and interdisciplinary (i.e. combination of academic perspectives), we seek to assess the transdisciplinarity of urban ecology. Transdisciplinarity is understood as knowledge integration that spans boundaries between disciplines and also those between scientists and professionals working in other domains (Staerdahl, 2002).

In keeping with contemporary theories of innovation (e.g., Etzkowitz and Leydesdorff, 1998; Edquist, 2001), commitment to transdisciplinarity stem from interests in making the boundaries of research universities and research processes more permeable. Linkages between scientists and practitioners—interaction among scientists and people working as policy makers, business professionals, urban planners, advocates and educators—are viewed as an important resource for enhancing productivity, creativity and relevance of urban ecological science (Pickett, 1997; Foresman, 1997; Hunter, 2001; May, 2004). In this spirit, our empirical assessment evaluates both intra-academic collaboration and the extent to which practitioners working outside of academic settings contribute to the scientific literature.

Urban ecology’s engagement with social problems

Beyond basic scientific inquiry and production of disciplinary knowledge, urban ecology makes explicit claims of engagement with policy-relevant questions. Urban ecology has

committed to a mission of increasing the health of the biosphere and human society (Lyons, 1997; Mazari-Hirart, 2000; Collins et al., 2000; Fouda, 2001). The Urban Ecology program at the University of Washington advertises its research and teaching program as “Linking science and policy to address real world challenges.” The Institute for Ecosystem Studies (IES) identifies its mission as providing “knowledge needed for [the] solution of environmental problems.” Applied specifically to its work within the Baltimore LTER project, IES seeks to “incorporate the urban ecological system in the sociopolitical decision making that influences the metropolitan environment.”

Beyond an assessment of the extent to which the urban ecology literature reflects engagement with social problems through production of applied research, we seek to evaluate policy models at work in the field. Policy models are sets of beliefs concerning the way the world and processes of social change work. We are interested in understanding the relative emphasis authors place on various strategies to effect change. In line with leading analyses of the evolution of environmental policy (Hempel, 1996; Mazmanian and Kraft, 1999; Kettl, 2002), these strategies can be crudely described as centralized and decentralized.

The centralized strategy corresponds to a classic formulation in which the state (i.e., government authorities) and various experts working in service of the state govern through regulatory mechanisms of command-and-control. The more contemporary strategy of decentralization emphasizes participation and the engagement of the business community and civil society in partnership with the state. Similarly, we can think of a set of policy models opposed to one another on the basis of the source of legitimate knowledge. As Fischer (2002) has analyzed tendencies in governance, traditional expert-centered or technocratic administration is now rivaled by more democratic models in which knowledge, values and perspectives of a range of actors are incorporated into policy. Through an empirical assessment of the intervention strategies recommended in the urban ecology literature, we seek to understand how this overarching debate regarding the nature of authority and politics is reflected in the field.

We now turn to an empirical assessment of the scientific literature. We evaluate the extent to which urban ecology reflects the three commitments we have described here.

- Extend the discipline of ecology through application of ecological theory and methods in human-dominated settings
- Engage in transdisciplinary practice by spanning academic boundaries and by engaging non-academic professionals in knowledge production
- Conduct applied research and engage in producing solutions to social and environmental problems

Methodology

The data we present derives from a systematic review of all articles that appeared in print in *Urban Ecology* and *Urban Ecosystems* between 1975 and 2004. This set of 261 peer reviewed articles is unambiguously relevant to the field, given the titles and status of the journals and their solicitation of manuscripts. Research relevant to urban ecology is published in a broad range of journals addressing various aspects of environmental science and natural resources management and policy (McIntyre et al., 2000). The scattered nature of the literature and the lack of widely shared keywords led us to reject a strategy of inclusion of journals that included, but did not specialize in urban ecology research.

Urban Ecology was published from 1975 to 1986. In 1986 it ceased publication and merged with the journal *Landscape and Urban Planning*. The latter journal includes some research on the urban environment, but its dominant focus is on landscape level analysis with a strong concentration on regional and hinterland studies. *Urban Ecosystems* began publication in 1997 with stated aims and scope very much in line with the programmatic statement of the Institute for Ecosystem Studies we used to structure this assessment. This set of 261 articles allows us to examine a core literature of urban ecology and to evaluate change over time.

Each article was read closely by the first author, and codes were assigned to record information relevant for our assessment. We categorize each article in terms of authorship, research setting, scientific orientation, empirical focus, and policy relevance. Although not free from subjectivity, this manual approach to analysis of texts was chosen in lieu of a computerized keyword search. Digital surveys based on key words or content analysis (i.e., Boolean logic used to search for text strings) can be misleading in two fundamental ways. Instances in which articles have relevant characteristics but lack specific keywords can lead to errors of omission. In other instances, electronic “trolling” can lead to inclusion of articles that contain key words, but are irrelevant with regard to the research question. As a result, computerized surveys of literature can suffer from “electronic subjectivity.” Additionally, because several of our assessment criteria require us to evaluate the character and content of the literature, as opposed to simply recording the presence or absence of one or more text strings, a computer-based approach was seen as unsuitable. See Table 1 for details of our coding procedures and definitions.

The procedures described here are an application of bibliographic research methods. Bibliometry is a means “to shed light on the processes of written communication and of the nature and course of development of a discipline (in so far as this is displayed through written communication), by means of counting and analyzing the various facets of written communication.” (Pritchard, 1969 p. 13, from Borgman, 1990). The most common application of bibliometry is citation analysis (i.e., who cites and is cited by whom), which is used, for example, to assess relational patterns in production of scientific knowledge. Applications have diversified over time, and bibliometrics are now used to assess research productivity

Table 1 Data fields and coding procedures

Article attributes	Coding
Research setting	Articles coded as either metropolitan (exclusively metro), regional (territories including both metro and non-metro locales) or global (not tied to particular locale) based on focus of data collection.
Disciplinary orientation	Discipline determined by theory, methods and analytic routines applied in research
Authorship	Institutional affiliation of authors recorded to assess interdisciplinarity (i.e., joint authorship by academics from two or more disciplines) and transdisciplinarity (i.e., one or more authors working in non-university professions)
Applied research	Articles which substantively engaged social and environmental problems
Identification of responsible parties	Articles that explicitly identified actors positioned to respond to social and environmental problems
Identity of change agents	Sectoral affiliation of actors identified as positioned to effect positive change

and track the evolution of scientific fields (Raisig, 1962; Borgman, 1990; Schubert, 2002; Uzun, 2002).

Results

Commitment to extend and expand the discipline of ecology

Research settings

Citing the opportunity to advance ecology by countering the historical bias against study of human dominated landscapes, we evaluated the centrality of *doing ecology in cities* within the urban ecology literature. *Ecology in cities*, is distinguished from *ecology of cities*, where the former examines the ecological patterns and process occurring within metropolitan settings and the latter focuses on the ecological effects of urban resource demands (inputs) and waste streams (outputs).

We further refined *ecology in cities* by evaluating the proportion of the published research that was conducted exclusively in metropolitan settings, as opposed to research conducted at regional scales (i.e., large geographic regions containing both metropolitan and non-metropolitan patches) and research not tied to a particular location or scale (e.g., theoretical and methodological articles, literature reviews, or those dealing with the global ecosystem as a whole), what we refer to in Figure 1 as global. Metropolitan is defined here as an urban complex, generally including urban core areas (i.e., downtown) as well as transitional areas (i.e., suburbs, industrial districts). We found that 52 percent of the articles published from 1975 to 1986 and 64 percent of those published between 1997 and 2004 report results of research conducted exclusively in metropolitan settings (Fig. 1). Results indicate a strong and increasing commitment to working in human dominated settings.

Application of theory and tools of ecology

We then went on to evaluate the centrality of ecological science within the urban ecology literature. While many academic disciplines are represented in the urban ecology literature (see Fig. 4), the status of ecology is strong and growing stronger. The percentage of articles grounded in theory and methods of ecological science has risen from 38 percent of those

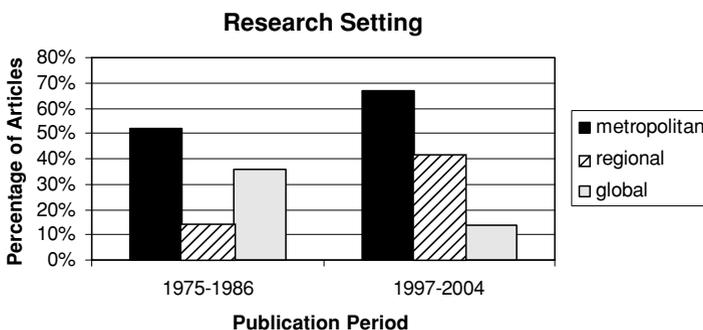
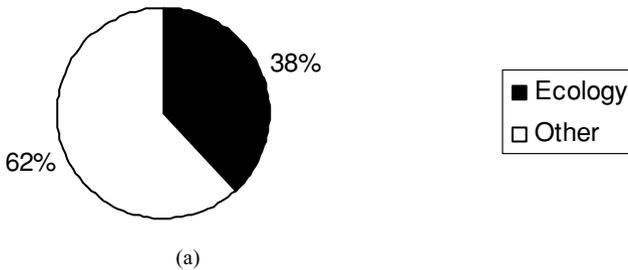


Fig. 1 Geographic foci of urban ecology articles, 1975–1986 and 1997–2004

Ecology Oriented Research: 1975-1986



Ecology Oriented Research: 1997-2004

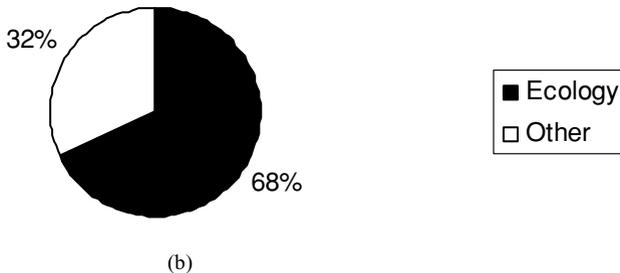


Fig. 2 Proportion of urban ecology articles grounded in ecological science, 1975–1986 and 1997–2004

published during the period from 1975 to 1986 to 68 percent of those published from 1997 to 2004 (Fig. 2).

Ecological research in metropolitan settings

Combining the two criteria outlined above, geographic setting and disciplinary orientation, we are able to assess the extent to which the urban ecology literature consists of doing ecology in human dominated settings. Over time this figure has risen from 23 percent for the period 1975 to 1987 to 34 percent from 1997 to 2004 (Fig. 3).

Boundary spanning

Multidisciplinarity

Urban ecology researchers draw on a variety of disciplinary traditions including biophysical sciences, social sciences and engineering (Fig. 4). Although ecology has been the dominant framework, sociology and planning have been well represented. Economics, engineering and psychology have played minor roles. While there was some degree of parity among the principal disciplines in the period of 1975 to 1987, expanded application of ecological

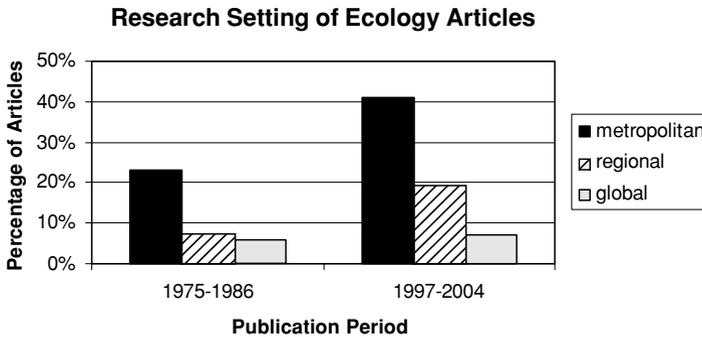


Fig. 3 Geographic foci of urban ecology articles grounded in ecological science, 1975–1986 and 1997–2004

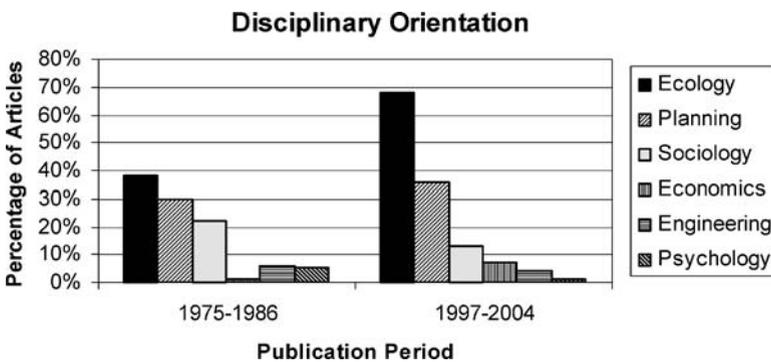


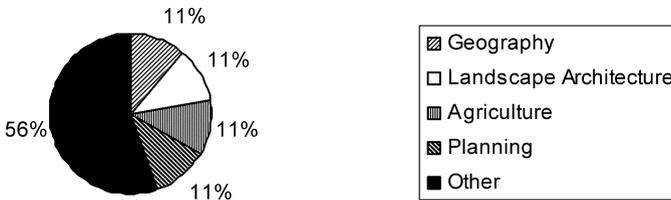
Fig. 4 Distribution of principle academic disciplines of urban ecology articles, 1975–1986 and 1997–2004

concepts and methods appears to be crowding out other analytic approaches in the period 1997 to 2004. Ecological frameworks were applied to 68 percent of all articles published in the later period, an increase of 30%. These data suggest that while the field can be described as multidisciplinary, it is increasingly less so.

Interdisciplinarity

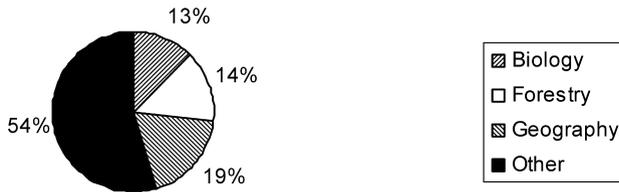
In addition to having more than one scientific discipline represented in the literature, urban ecology is characterized by a degree of interdisciplinarity, as represented by research collaboration across disciplines. We identify articles as interdisciplinary if two or more co-authors record different academic departmental affiliations. By this definition, solo authored articles and articles for which institutional affiliations are not recorded for all authors are not treated as interdisciplinary. Authors from twenty nine different academic fields participated in jointly authoring papers in our sample, including collaborators in entomology, marine biology, hydrology, liberal studies, education and psychology. During the period from 1975 to 1986, 27 papers (19% of all papers) were products of interdisciplinary collaboration. Scientists in geography, landscape architecture, and agronomy departments were the most frequent collaborators (Fig. 5). From 1997–2004, 64 papers (60% of all papers) were interdisciplinary collaborations. Geography, forestry and biology departments were the most frequent collaborators. We note that the literature is increasingly interdisciplinary.

Interdisciplinary Authorship by Discipline: 1975–1986



(a)

Interdisciplinary Authorship by Discipline: 1997–2004



(b)

Fig. 5 Proportion of urban ecology articles with interdisciplinary authorship, by discipline, 1975–1986 and 1997–2004

Transdisciplinarity

While academics predictably dominate, engagement of people outside of university settings in publishing scientific articles has increased over time (Figure 6). The percentage of articles jointly authored by academics working with non-academics has increased as well. Conversely, the percentage of articles authored only by academics, including solo and multiple authored papers has declined from 72% in the period 1975–1987 to 52% from 1997 to 2004. However, there may be a swing back toward academic hegemony, as the increase in non-academic authorship we report for the period 1997–2004 masks a sharp decline in the period 2000–2004. Given the limited amount of data and the short time span, it is difficult to interpret this information.

We note that people working in civil society organizations (e.g., professional organizations, foundations, and non-governmental organizations) have begun to collaborate more frequently in scientific publishing as represented by increased engagement in the period 1997–2004. Also, collaboration between academics and government personnel has been a growing trend. While quite rare, we see evidence of three-way scientific collaboration among academics, government personnel and representatives of civil society.

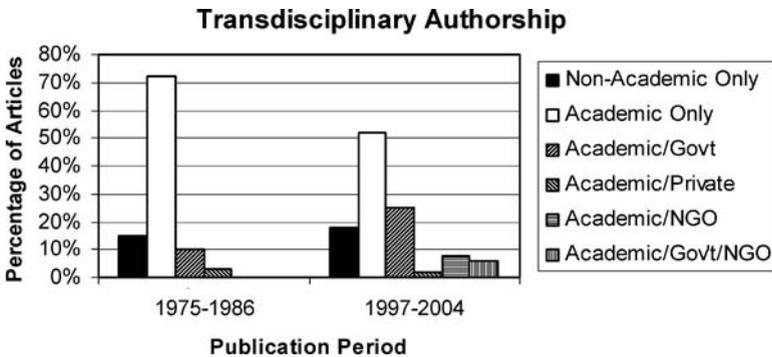


Fig. 6 Distribution of collaborative authorship of urban ecology articles, by professional categories, 1975–1986 and 1997–2004

Applied research and policy engagement

Applied research

Forty nine percent of the articles published between 1975 and 1987 addressed specific social or environmental problems. This figure jumped to 86 percent during the period from 1997 to 2004. Clearly, a tradition of applied research is strong and growing within the field of urban ecology.

Problem solving and policy engagement

In order to evaluate the extent to which urban ecology practitioners have inserted themselves in the policy process, we analyzed the frequency with which authors offered specific prescriptive recommendations regarding which actors should have responsibility for addressing particular social and environmental problems. Our coding scheme included government (legislative, judicial and executive actors), urban and environmental planners, the research community, civil society and community groups (NGOs) and commercial businesses. Thirty eight percent of the papers published between 1975 and 1987 made such prescriptions. That number rose to seventy one percent during the subsequent publication period.

Who should lead?

We examine the frequency of identification of various social actors in urban ecology policy prescriptions to assess the popularity of various policy models, as identified in the governance literature (e.g., Fischer, 2000; Mazmanian and Kraft, 2001; Kettl, 2002). As described earlier, we are particularly interested in the relative emphasis placed on classical policy responses (i.e., regulatory actions designed and enforced by the state and associated experts) and contemporary participatory strategies in which private businesses, non-governmental organizations (NGOs) and community groups occupy increasingly prominent positions.

While government intervention is clearly the dominant prescription, we find that each of the potential “change agents” is recognized (see Figure 7). Classical modes of intervention dominate in both publication periods. Researchers identified government, planners and researchers as responsible in 46 percent of articles published between 1975 and 1987 and 92 percent of articles published from 1997–2004. Frequency of identification of community

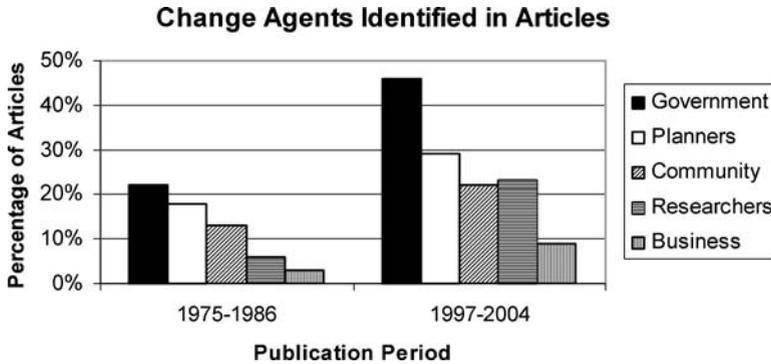


Fig. 7 Distribution of identity of parties identified in urban ecology articles as positioned to respond to social and environmental problems, 1975–1986 and 1997–2004

groups and businesses rose from 20 percent to 30 percent across the two periods. Most of this increase is accounted for by private businesses which were identified as relevant to solutions three times more frequently in 1997–2004 relative to 1975–1987. We note that the research community experienced the largest relative increase in frequency of identification as an agent of change (400% increase).

Discussion and conclusions

Results indicate that the three tenets of urban ecology we used to structure our bibliometric analysis are strongly reflected in the scientific literature. These commitments are a useful description of the field, its evolution and its trajectory. At a general level, it is fair to say that, as a field, urban ecology is extending ecological science in a novel direction. It is substantially multidisciplinary, interdisciplinary and transdisciplinary. And, it is policy-relevant. Each of these claims is discussed below.

We found that in the contemporary period (1997–2004) one third of all published articles are products of *doing ecology in cities*. This proportion has increased over time. Thus, it can be argued that the field has increasingly come to be focused on analysis of ecological patterns and processes within metropolitan areas. This stream of work will contribute to correction of the bias in ecology against doing field work in human-dominated settings. Extending ecological theories and methods for application in non-traditional settings will broaden the discipline. More thorough incorporation of human disturbance into ecological thought and knowledge will strengthen ecology, particularly given expanding recognition that social processes and human behaviors are an unavoidable driver of environmental change across a variety of scales.

Having drawn this conclusion, the fact that two thirds of all published articles cannot be defined as applications of ecology in urban settings points to diversity in the research portfolio. Urban ecology research draws on a range of academic disciplines as well as contributions from people working outside of academia. This is in keeping with a commitment to spanning boundaries so as to enhance creativity, innovativeness and practical value. The rise in published papers by non-academic researchers and by collaborations involving academics and non-academics are particularly encouraging in this regard. The literature appears to reflect and advance a dialogue among analysts and practitioners. Such collaboration suggests progress toward creation of a shared, deliberative policy arena, precisely the kind of structure

increasingly regarded as necessary to make progress toward sustainable development (e.g., Hajer and Wagenaar, 2003).¹

Although successful in demonstrating academic eclecticism or heterodoxy, some troubling trends are reflected in these authorship data. The downturn in collaboration between academic and non-academic authors in the final four years of our study (2000–2004) is of concern, as it points to a possible disconnect among potentially important partners in research and problem solving. In addition, the substantial rise in research grounded in the discipline of ecology addresses urban ecology's first commitment (to expand the field of ecology), but appears to be coming at the expense of the engagement of other disciplines, its second commitment. In other words, there is an element of a zero-sum game, as ecology's rise in the field—over 65% of articles in the contemporary period (1997–2004) are grounded in practice of ecology—is paired with a decline in levels of engagement of other disciplines. This pattern of disciplinary specialization suggests a tendency toward reduced diversity and a potential failure to maintain a boundary spanning scientific field.

The finding of loss of intellectual diversity over time invites speculation regarding the nature of the university and science more generally. Research other than disciplinary research has long been recognized as having low status in academic hierarchies, and incentive structures have long been identified as a mechanism that perpetuates a “tyranny of the disciplines.” It is quite reasonable to hypothesize that individual researchers and academic units gravitate toward activities more richly rewarded, toward research programs more easily funded and toward problem foci more easily to legitimate in the currency of the university. Further, we might speculate that it is easier to pursue a more heterodox program at the time of founding of a scientific field, but as a scientific field matures and attracts more resources, institutional pressures mount to promote conformity with standard (i.e., disciplinary) modes of scientific practice. More research is needed to evaluate potential costs of ecology's growing interest in urban environmental dynamics and management.

While we offer qualified affirmative responses as to whether urban ecology is meeting its first and second commitments—extending ecological science and spanning traditional academic boundaries—it is quite clear that the field is applied in orientation and substantially engaged in policy-relevant research. This tendency has increased over time, as over 85% of the papers published from 1997–2004 addressed a social or environmental problem. Furthermore, the literature has become increasingly engaged in offering policy prescriptions, as nearly three quarters of the papers published in this same period specified the set of actors best positioned to effect change.

Policy prescriptions were varied, as researchers called for both state-centered and non-state-centered modes of intervention. The state is seen as the central actor responsible for social controls. At the same time, there was expanded interest in engagement of commercial businesses, civil society organizations and community representatives in participatory modes of policy formulation and implementation. These findings indicate that policy models at work in urban ecology, and the evolution of these models, are very much in line with general tendencies in governance.

Perhaps the most interesting tendency in terms of policy prescriptions is the rise in identification of researchers as having roles in policy processes. Rather than viewing themselves strictly as technical analysts with no roles in political processes and outcomes, researchers apparently seek to insert themselves and their disciplines into policy processes (e.g., Kaiser,

¹A deliberative policy arena has been metaphorically described as an agora—the marketplace of the ancient Greeks in which goods and ideas were exchanged among diverse parties and the legitimacy of competing claims regarding the validity of knowledge was fruitfully debated (Fredericksen et al., 2003).

2000). Clearly, our bibliometric analysis is limited in that these data do not inform our understanding of policy roles occupied or sought by urban ecologists. Specifically, we do not know whether the type of policy entrepreneurship we document here extends into what Frickel (2004) has labeled activist environmental science (i.e., environmental scientists adopting advocacy roles and taking public stances on politicized issues).

This reflexive assessment of the urban ecology literature was designed to assess correspondence between scientific output and a set of programmatic objectives that define and direct investment and practice in the field. Results can support critical reflection regarding weaknesses we have identified, as well as more fundamental discussion as to if and how the intentions of the field have been or need to be updated. More positively, results could be useful in efforts to attract investments by funders and researchers interested in building on the considerable achievements and promise of urban ecology. Future research should seek to contextualize these bibliometric results through application of historical and ethnographic techniques and other methods that bring us closer to the actors and the practice of science.

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