# CHAPTER 1

# Urban ecology – brief history and present challenges

Ulrike Weiland[1] and Matthias Richter[2]

[1] *Institute for Geography, University of Leipzig, Leipzig, Germany*
[2] *Environmental Scientist, Publicist and University Lecturer, Germany**



## 1.1 INTRODUCTION

Urban ecology plays an important role in understanding urban systems. In order to analyze and apprehend, for instance, urban land use changes and their impact on the regional water balance, the role of urban green spaces for the local climate, conditions for the coexistence of species in an urban setting, or resource fluxes and opportunities to reduce and optimize them, it is necessary to know how urban systems function and how and to what extent they both impact and are affected by global or regional processes. Urban ecology is characterized by a variety of approaches. It is an interdisciplinary research field at the interface of natural sciences, social sciences and humanities as well as engineering. As an interdisciplinary research field urban ecology investigates the interrelations between environmental compartments and human activities such as construction, production, housing, and transport. As an applied scientifically based approach, urban ecology gives hints about where and how the urban environment may be protected from further harm, and how environmental quality and thus physical human living conditions may be improved.

Today's urban ecology differs widely from its beginnings. Its traditional lines have a close connection to the scientific and social context of their time as well as to the respective urban structures. Five traditional strands of urban ecology can be differentiated by analyzing their preferred research aims, their scientific approach, and their research motives; they occur partly in parallel but at the same time. Knowledge of the history of urban ecology is helpful in order to understand the recent approaches presented in this book; therefore general lines of tradition of urban ecology will be discussed first in the following prior to depicting present challenges (Richter and Weiland 2008, Weiland and Richter 2009).

*Contact information: http://www.Dr-Matthias-Richter.de

## 1.2 BRIEF HISTORY

### 1.2.1 Initials in urban natural history

The beginning of urban ecological research is rooted in 16th century observations of nature in cities when spontaneously growing species in the cities drew the attention of botanists to stone walls, castles, and ruins, which were identified as the first ''habitats'' (Sukopp 1994, 2002). Since the notion of ''urban ecology'' did not yet exist at that time, this approach has been called the ''line of tradition rooted in natural history'' (Weiland and Richter 2009, p.50). At that time the European city was characterized by a very high building density within the city walls. Extensions of the built-up area set up the preconditions for further urban development (Mumford 1963, Lichtenberger 2002). Knowledge of the medical use of herbs was widespread. Thus, it is not surprising that interest in acquiring knowledge about nature was applied to cities at these

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early times. Today, this traditional line continues as a partial aspect of bioecological (e.g., Penev *et al.* 2005) and biogeographical research approaches (e.g., Wania *et al.* 2006).

### 1.2.2 Socioecological tradition

During the industrialization phase, the sociology branch of the Chicago School had a major influence on the development of urban ecology. In the 1920s Chicago was in the heyday of industrialization, and was a typical example of the rapidly growing, unsanitary industrial cities of the 19th and early 20th centuries in North America and Europe, with extremely high-density tenements, deficits in water supply, sewage and waste disposal, poor air quality, and poor lighting conditions. These conditions and their consequences provoked Robert E. Park to commence his socioecological studies, which were strongly influenced by Georg Simmel and Max Weber, amongst others (Park *et al.* 1925). The Chicago School investigated the interrelations between city and society, in particular the living conditions of the industrial workers. Robert E. Park and Ernest W. Burgess tried to explain the urban development processes of Chicago and their impacts on social groups by means of a human–ecological or ''quasi biological'' research approach (Feagin 1998, p.2) using theoretical concepts of animal and plant ecology: e.g., succession, symbiosis, competition, and adaptation (Kurtz 1984, p.21). They explained phenomena such as migration and segregation phases of different population classes and social minorities with the help of ''invasion-succession cycles'' and city structure models. This approach has been profoundly criticized because of its biological basis. Later on, the socioecological tradition of urban ecology was superseded by a collateral human ecological perspective (e.g., Winter and Mack 1988, Fellenberg 1991).

### 1.2.3 Complex bioecological tradition

The perception of the finite nature and instability of the supply of fossil resources increased after the climax of the economic boom in the United States and Europe that followed the Second World War. As a consequence, urban ecology received much more attention than before. In the 1970s Herbert Sukopp and a group of colleagues developed a complex bioecological approach to urban ecology (e.g., Sukopp 1973, 2005). In its early years, the Berlin School of Urban Ecology carried out mainly ecological site analyses and field botany research on wasteland that existed in great quantities in Berlin in the years after the Second World War. Its approach, which maintains urban flora, fauna, and habitats as its core, can be considered a more versatile strand of the line of tradition rooted in natural history. In this approach humans influence and superimpose natural habitat conditions, especially in the form of land use and land use changes. Research is centered on organisms, species, and their habitats; additionally urban climate, soil, and water bodies are investigated, mainly as habitat conditions for urban flora and fauna. Humans play a role as a source of disturbance and as users of urban nature, above all for recreational purposes. A further central and application-oriented motive for research is to transfer nature conservation to cities and urban areas in order to protect urban nature for the human inhabitants. Further research approaches that can be considered to be examples of this line of thought are presented, for example, by Wittig (1991) and Gilbert (1989).

### 1.2.4 Ecosystem-related tradition

During the same time period as the Berlin School of Urban Ecology, an (eco-)system related tradition of urban ecology evolved on an international level. This approach is highly influenced by American and German landscape ecology (Tansley 1935, Troll 1939, 1968, Schmithüsen 1942, Neef 1967) and systems theory (von Bertalanffy 1953), the systemic approach linking both research directions; later influences can be characterized by the keywords ''patterns and processes.'' Major international research programs such as UNESCO's Man and the Biosphere Program (MAB) (Spooner 1986) and the International Biological Program (IBP) initiated large research projects in this area. The ecosystem-related tradition is heterogeneous; two main directions can be distinguished.

#### The first direction: ecological analyses of urban landscapes

Landscape ecological studies were assigned to cities and city sectors with the aim of identifying ecological patterns and processes. Within this theoretical framework, a long history of approaches focuses on the analysis of

urban–rural gradients (McDonnell and Pickett 1990, Kinzig and Grove 2001). Studies of metapopulation theory, which also have been carried out in cities since the 1990s, often show overlaps between organism approaches and landscape ecology approaches (Niemelä *et al.* 2002). Further research projects focus on the interrelations between urban structures and compartments of the urban natural environment (e.g., Breuste *et al.* 1998).

### The second direction: analyses of urban material and energy flows

The *Fundamentals of Ecology* (Odum 1953), serving as the scientific basis of this research approach, explains physical and chemical processes of aquatic, terrestrial, and anthropogenic ecosystems using a systems approach. Research is not focused on organisms, but on substances and material flows. From the 1970s onward, energy flows were also included, induced by the oil crisis that promoted awareness of the impermanent character of natural resources. Independently from each other, the ecologist Howard T. Odum (1953) and the urbanist Lewis Mumford (1963) influenced architects as well as urban and regional planners in the subsequent ecological movements – triggered by the Club of Rome's publication *Limits to Growth* (Meadows *et al.* 1972) – to take into consideration both the cultural–historical and the ecosystems approach in their plans and concepts. Material and energy flow studies of, for example, Brussels (Duvigneaud 1974) and Hong Kong (Boyden *et al.* 1981) were conducted (see also Baccini 1996). Since then, cities have been considered ''importers'' and ''intermediate stores'' (Baccini and Bader 1996) of large masses and of a variety of resources (Chambers *et al.* 2001). Quantitatively the most important fluxes are those of energy, water, food, and building materials. Since recycling processes barely exist, warmth, waste water, garbage, and waste air are deposited, pass through the urban environmental systems and cause local, regional, and sometimes global environmental problems (Davíla and Atkinson 1999). The most important merits of this approach include its contribution to an increased understanding of how (and which) substances accumulate in different ecosystem compartments (e.g., urban soil, ground floor vegetation, trees) and how they can become dangerous for plants, animals, and humans via food webs. Furthermore, the identification and quantification of regional to global material and energy fluxes has increased the understanding of global interconnectedness of the single city, not only in economic aspects, but also with respect to resource flows and environmental pollution.

#### *Long-term ecological research (LTER) sites*

A considerable step forward in international recognition of urban ecology can be attributed to the interdisciplinary research teams at the Long-Term Ecological Research (LTER) sites in Baltimore and Phoenix in the United States and to cooperating research groups (Alberti 2008, Grimm *et al.* 2008, Marzluff *et al.* 2008). The research on urban LTER sites also can be traced back to the ecosystem-related tradition and at the same time it deepens the urban ecological knowledge and enriches it by using up-to-date techniques.

The urban ecology research program in Baltimore, Maryland, seeks to understand an urban region as an ecological system and investigates

**1** the relations between spatial structures of socioeconomic, ecological, and physical features and their changes over time,

***2*** the fluxes of energy and matter as well as human influences on these, and

**3** options to improve the quality of the urban environment.

The urban ecological research program in Phoenix, Arizona investigates the structures and functions of an urban ecosystem in an arid environment – the Sonoran Desert – and aims at understanding the distribution and perception of ecosystem services in the metropolitan region of Phoenix (see Chapter 4). Urban ecology, according to this research approach, considers urban agglomerations as complex systems with integrated social, economic, ecological and technical subsystems. It analyses, for example, socioecological drivers of land management and ecosystem responses, nitrogen fluxes as well as social vulnerability, environmental inequity and health (ASU 2011).

## 1.3 RECENT AND PRESENT CHALLENGES

Several main steps forward in urban ecology can be observed in recent times: on the one hand, urban ecological research is increasingly carried out in international settings, parallel to economic globalization, while most research activities are still based in North America and Europe (Deeter 2003). On the other hand, a tendency of convergence of research themes and methods

can be observed, although the orientation of urban ecological research towards ecosystem research is stronger in North America than in Europe (Zipperer *et al*. 2000).

Furthermore a complex systems approach to cities and their ecology has become common within the majority of the scientific community. Today, cities are considered to be coupled complex human and ecological systems. They are characterized by non-linear development over time with unforeseen changes and leaps forward, and new emerging properties. Multiple agents, feedback mechanisms and their variability in time and space imply complexity, heterogeneity, and surprise as inherent characteristics of urban ecosystems. As a consequence, their behavior is not exactly predictable and prognoses are uncertain (Alberti 2008, p.225 ff.). Urban risks as well as vulnerability and resilience of urban systems represent recent research issues. These advancements in urban ecological research correspond with the growing challenges to urban ecology posed by the larger urban impacts on the environment.

Today, urbanization, i.e., the change of lifestyles, and urban growth, metropolization and mega-urbanization are dominant urban development processes in most parts of the world. Since 2008, the majority of the world population is urban[1], and in 2050, this share is expected to be 70%. The 21st century is addressed as the ''urban century'' (UN ESA 2008).

Urban areas are subject to large-scale influencing factors such as economic, sociodemographic, technological, and environmental change, referred to as global, demographic and climate change. They imply chances and risks for the cities and urban agglomerations.

In regard to this, urban development processes are characterized by a large variability; dynamically growing agglomerations contrast with economically weak and stagnating cities, whereby growth and shrinkage processes also occur at the same time within cities. In (former) industrialized cities large brownfield areas remain as relicts of the Industrial Age comprising socioenvironmental risks as well as opportunities for new beginnings.

From an environmental point of view, urban sprawl (urban expansion up to the ''networking of cities''), causes not only an increase of resource use, but also a fragmentation of landscapes and the loss of natural areas. Economic activities and transport lead to environmental pollution far beyond the physical and administrative urban borders (Hall and Pfeiffer 2000). Urban growth and urbanization are changing a growing number of natural or seminatural habitats and former agriculturally productive areas, for example, by producing heat islands, causing water pollution, and by contributing to desertification. Urban systems are ''flow-through systems''; by far the largest part of energy and material fluxes of the human economy returns in an altered form as pollution and waste to the ecosphere. A number of scientists, prominent among them Saskia Sassen, consider that ''this makes cities a source of most of the environmental damage, and some of the most intractable conditions feeding the damage'' (Sassen 2009, p.46). However, it is not urbanization *per se* that necessarily causes negative impacts on the environment, but rather the particular types of urban systems and the way of industrial production as well as deficits in urban governance. Since cities are not only polluters, but also sites for innovation, it is ''within the complexity of the city that we must find the solutions to much environmental damage and the formulas for reconfiguring the socioecological system that is urbanization. [. . .] Cities make the multi-scalar property of ecological systems present and recognizable'' to decision makers and urban inhabitants. As a consequence, improving the urban environment and reducing the environmental impacts of urbanization on regional, national, and the global environment entails a multi-scalar approach (Sassen 2009, p.46).

Global urbanization and its unintended negative effects, not only on the urban environment and the urban dwellers, but also on the entire environment, necessitate sustainable urban development on various scales. Habitat Agenda and Agenda 21 contributed to establishing a common understanding that cities rebound to global and local environmental problems and are a potential arena in which to address sustainability. Many cities try to implement sustainable urban development (c.f. extensive database in IISD 2010); it is about – according to Agenda 21 (UNEP 1992) – integrating ecological, economic, social, and cultural aspects of urban development in a long-term perspective, including good human health conditions. Sustainable urban development requires the cooperation of a variety of authorities, stakeholders, and social groups on different political levels, including the heads

[1]The definition of ''urban'' differs between countries; here it depicts the percentage of the total population living in areas termed ''urban'' by the respective country. The definitions range from population centers of 100 or more dwellings to only the population living in national and provincial capitals.

of international organizations and consortia. It applies to the local level while considering regional, national and global interrelationships, because the ecological regulation of cities can no longer be separated from wider questions of regional, national, and global governance. Sustainable urban development is a goal of political negotiation with no foreseeable end point (Grunwald and Kopfmüller 2006, Atkinson *et al.* 2007, Girardet 2007).

Considering the differences between cities and the variety of urban development processes, it becomes obvious that the general meaning of sustainable development has to be transferred to the prevailing local conditions, and that every city has to find its own way of striving for sustainability. As a consequence, differing understandings of sustainable urban development exist; the complexity of the integrated model and its need for interpretation are both its characteristic and its problem. In Europe important objectives are, for example, mixed urban development and the ''city of short distances'' (*Stadt der kurzen Wege*) in order to avoid further urban sprawl (Baccini and Oswald 1998, Oswald and Baccini 2003). The large amount of public awareness that the sustainability discussion enjoyed in the 1990s has diminished to date due to changes in the relevance of issues on the political agenda. Nevertheless, sustainable urban development has never disappeared from the political agenda; international organizations work on its implementation, and the scientific discussion has never broken off (Girard *et al.* 2005, Elliott 2006, Atkinson *et al.* 2007, Girardet 2007).

Parallel to the sustainability discourse, but only partly linked to it, and only indirectly referring to urban ecology, the discourse on ''new urbanity'' has spread among architects and planners in North America and Europe since the 1980s (Häußermann and Siebel 1995, Swyngedow *et al.* 2002, Oswald 2003). ''New urbanity'' is understood as ''the way of living of the majority of people in developed countries'' that is ''based on modern technical, social and organisational preconditions'' (Oswald and Baccini 2003, p.291). It is an alternative draft to the decline of heavy industry, river- and seaports, to suburbanization and urban sprawl. The concept of ''new urbanity'' is multifaceted: urban reconstruction, revitalization of urban brownfields, rebuilding of historic townscapes, and the rediscovery of urban waterfronts characterize the concept. Some examples are the Docklands in London and Dublin, Kop van Zuid in Rotterdam, or Harbour City in Hamburg.

Both concepts ''sustainable urban development'' and ''new urbanity,'' have an influence on urban development that is difficult to measure and mostly concentrated in scattered projects. In the majority of cases ''new urbanity'' specifically addresses urban ecology only indirectly. Nevertheless, urban environmental research has been carried out and discussed more frequently under the aspects of resource protection and diminution of environmental pollution aiming at equal opportunities for future generations, which are considered constituent parts of the integrative concept of sustainable (urban) development (IWM EB 2002, Marchettini *et al.* 2004, Mander *et al.* 2006, Weiland 2006, Kennedy *et al.* 2007).

At the International Conference of Urban Ecology in 1997 in Leipzig, a broad scope of issues related to urban ecology, the perception of urban ecological issues by urban citizens, and policy approaches were discussed (Breuste *et al.* 1998). Furthermore, ''redesigning the urban metabolism in view of sustainability goals'' is considered a relevant research question for urban ecology (Brunner 2007). These examples show that urban ecological research has both thematically expanded compared to previous decades and has also shifted towards investigating the applicability of research findings in urban decision making (Baccini 1996, Alberti *et al.* 2003, Pickett *et al.* 2004, Müller *et al.* 2008).

## 1.4 PURPOSE AND STRUCTURE OF THE BOOK

### 1.4.1 Purpose of the book

This book *Applied Urban Ecology – A Global Framework* bridges the gap between theory and practice and presents a broad spectrum of urban ecology approaches from systems research to environmentally sound urban design, exemplified by selected case studies from different continents. This claim is met by engaging experts from geographically different parts of the world (in alphabetical order): from China, Germany, India, the Netherlands, New Zealand, South Africa, Sweden, Switzerland, United Kingdom, and the United States, and by including widely acknowledged scientists on a keynote speaker level accompanied by up-and-coming scientists. The conception of the book derives from a 5-year study ''Urban Ecology – an International Comparison'' and an investigation of the preferred up-to-date research questions at large research institutions.

Based on this study, the book portrays a range of recent approaches to urban ecology and focuses on providing knowledge and expertise for the application of urban ecological findings. *Applied Urban Ecology – A Global Framework* is a contribution to support the improvement of environmental quality in urban settings by mutually learning from other attempts.

The purpose of this book is to provide urban ecological knowledge in a nutshell tailored to supporting environmentally sound urban development and based on a sound theoretical and contextual framework, including case studies. It is conceived as a textbook targeted for an international readership, especially for advanced students and PhD students, researchers, and experienced practitioners in the fields of urban ecology and landscape ecology, urban environmental research, environmental geography, urban planning and landscape architecture, and sustainable urban development.

### 1.4.2 Structure of the book

The structure of the book reflects the variety of approaches to modern urban ecology.

#### Parts I–II

In Part I ''Introduction'', Ulrike Weiland and Matthias Richter lead into the subject matter of the book by portraying urban ecological research approaches briefly within the context of their respective societal context, and by depicting recent and present challenges to urban ecology.

In Part II ''Urban Ecology: Related Disciplines and Methods'', Matthias Richter and Ulrike Weiland give an overview of disciplines and methods related to urban ecology. Ellen Banzhaf and Maik Netzband discuss opportunities of monitoring urban land use changes with remote sensing techniques.

#### Part III

In Part III ''Selected Fields of Applied Urban Ecology'' case studies on various topics from different parts of the world are presented. It becomes obvious that in different countries different problems are on the agenda of urban ecologists. It is of the utmost importance to be aware of the ways in which urban ecological topics are determined and constructed, as well as the respective goals of research. The following issues are addressed:

***Pathways of the ecosystem approach***

The ecosystem approach has been one of the most influencing research pathways in the field of urban ecology during the last 25 years. Pathways of the ecosystem approach are discussed from two different perspectives. Jianguo Wu and his co-authors report about the research experiences in long-term research areas that are in the framework of the LTER network in the United States: Baltimore, Maryland and Phoenix, Arizona. Another prominent pathway of the ecosystem approach is represented by the work of Peter Baccini. He shows how sustainable use of substances and energy in the urban area should be combined with urban planning, thus leading to a resource-sparing urban development. This approach uses the ''Schweitzer Mittelland'' as a case study.

***Socioenvironmental threats***

The focus in this section is on changes in urban areas resulting in socioenvironmental consequences and it explores the question of how everyday life for humans is influenced. The chapters cover a wide range of urban environments in industrialized countries as well as developing countries and sheds light on different types of socioenvironmental and health threats. Surinder Aggarwal and Carsten Butsch show how the growth of Indian mega-cities has been and is being accompanied by severe environmental problems and health risks, especially related to air and water pollution and poor sanitary conditions. Dieter Rink and Harriet Herbst highlight abandoned green open spaces from different perspectives including socioecological aspects. The different meanings of urban wilderness for citizens are contextualized in their contribution.

***Flooding and climate adaptation***

In recent times global change has been a more intensively discussed topic in general and this also influences its relevance for urban ecology. Therefore, this up-to-date topic is included. Dinand Alkema and Norman Kerle report about their experiences with flood risk assessment in Southeast Asian cities, such as Naga, Philippines. They use different methods (e.g., GIS and scenario techniques) for warning urban citizens about

different types of flooding. Marialena Nikolopoulou demonstrates how urban open spaces can be adapted to climate change using her case studies from different parts of the world.

***Urban biodiversity***

Urban biodiversity is one of the key topics in urban ecology. Especially in Central Europe, there is a long research tradition in urban biodiversity. More recently, this topic is often connected with socioeconomic activities. Sarel Cilliers and his coauthors write about the connection between biodiversity in selected urban areas of South Africa and local land use management practice, which has been shown to be class- and income-dependent. Maria Ignatieva demonstrates that globalization, combined with the dispersion of plant material, results in problems for locally adapted native species. Despite these negative influences she names techniques and examples from Russia, the United States, and New Zealand showing how to foster native biodiversity.

***Environmental urban design***

Design and planning of urban green and open spaces are the focus of this section. Kongjian Yu demonstrates that planning for green infrastructure can guide city planning and describes how this is implemented in growing Chinese cities. He combines and applies the principles of landscape urbanism with Feng Shui for his planning attempt. Landscape planning and landscape design for urban areas are mostly separated procedures originating from different disciplinary backgrounds. Antje Stokman and Christina von Haaren are building a bridge between these two disciplines and show how they should be linked for win–win situations and advantages for users.

***Environmental urban politics***

The availability of water, its quality and quantity, is one of the major environmental challenges for the future. Many of the conflicts are combined with the distribution of political power and how this is negotiated. Originating from a strongly coined ''natural science background'', urban ecologists are in the process of integrating governance aspects into their research. Alex Loftus compares different attempts of solving water conflicts in selected urban areas in South Africa and South America. Here the suitability of public, private or intermediate water supply is addressed. This is discussed by taking into account the differing political background of capitalism and socialism.

**Part IV-synthesis**

The synthesis in Part IV drawn by Matthias Richter and Ulrike Weiland provides a cross-cutting assessment of the approaches presented before. The findings from different parts of the world are reflected against recent challenges of urban ecology. Conclusions are drawn regarding how to improve urban environment taking into consideration the findings of urban ecology research. Hence a framework for ''urban green governance'' and for supporting an ecological urban development is presented, which is focused on relevant and up-to-date knowledge.

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