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PREFACE

Applying landscape ecological principles in urban environments

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Urban dwellers have long been interested in the interactions between humans and nature. Already 100 years ago concerns were raised about the fate of urban flora in the rapidly expanding city of Helsinki in Finland (Brenner 1906), but ecologists largely ignored urban areas for most of the twentieth century (Grimm et al. 2008). Lack of research has resulted in ecology contributing little to solving urban environmental problems or providing understanding for planning and management (Niemelä 1999; Grimm et al. 2008).

Systematic urban ecological research started only about 50 years ago. Berlin in Germany was one of the first cities to be studied comprehensively (Scholz 1956), and urban ecological research has its longest traditions in Central Europe and the UK (Sukopp 2008). More recently, similar surge of interest has taken place across the world. For instance, the journal *Landscape Ecology* has recently published numerous papers on urban landscape ecology. With the expansion of cities worldwide, knowledge of the ecology of cities integrated with social science approaches to guide the development of sustainable cities is urgently needed (Wu 2008; Grimm et al. 2008).

From an ecological perspective, cities are unique mosaics of sites which are constructed for residential, commercial, industrial, and infrastructural purposes, interspersed with green spaces. Urban green spaces are diverse, and include, for instance, parks, gardens and recreation venues. In addition to these formal green spaces, cities include informal green space, consisting of remnants of less modified, indigenous vegetation types, as well as specific urban habitats, such as derelict industrial sites, overgrown gardens, and ruderal sites (Breuste 2003). This mosaic of habitats can be fruitfully studied and understood using landscape ecology as a framework (Wu 2008).

Landscape ecology provides approaches and methods for understanding the dynamics of urban green spaces. Urban habitat patches are small and isolated from each other by a matrix of built environment. Ecological theories that have been used to examine such "archipelagoes" of urban green spaces include island biogeography theory (MacArthur and Wilson 1967). The findings of several urban studies (e.g., Klausnitzer 1993) of a positive relationship between patch size and species richness suggest that the theory of island biogeography could be an appropriate framework for urban ecological research as a first

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exploration of the relationship between species richness and characteristics of urban habitat patches.

The metapopulation theory (Hanski and Gilpin 1991) appears to provide another promising framework for urban ecological studies. The patchiness of urban green areas makes dispersal, a central theme of metapopulation theory, difficult and risky at least for taxa with poor dispersal ability. Consequently, the extent of green areas and their connectivity is an important factor affecting species occurrence in urban landscapes (e.g., Davis 1978). In particular, less mobile species, such as non-flying and ground dwelling arthropods, have difficulties in dispersing among isolated patches (Gilbert 1989).

Although urban green spaces are isolated and small, the landscape-level species richness is often high in urban settings. This is due to variation in species composition among patches (beta diversity), which in turn is a result of a high variety of habitat types ranging from semi-natural to highly anthropogenic ones (Rebele 1994). For instance, in Helsinki, beta diversity of plants was higher among urban habitats (parks, ruderal sites, and wastelands) than among semi-natural forest sites outside the city (Tonteri and Haila 1990).

Another ecological theory applicable in urban landscapes is the "intermediate disturbance hypothesis" (Connell 1978) predicting that species richness is higher in intermediately disturbed sites than in heavily disturbed or undisturbed ones. For instance, species richness and Shannon diversity of butterflies peaked at moderately disturbed sites across an urban–rural gradient in California (Blair and Launer 1997). The pattern has also been documented for birds (Jokimäki and Suhonen 1993), but studies on carabid beetles have shown controversial results (e.g., Niemelä et al. 2002).

Research based on landscape ecological theories can provide guidelines for urban planning, and management. For instance, connectivity between green areas can be improved by creating movement corridors and greenways. However, as noted by Noss (1993), greenways and corridors should not substitute for the protection of large, intact nature reserves in the urban or suburban landscape as such areas are needed for the maintenance of populations of the more sensitive species and as source areas for colonists (Niemelä and Halme 1998; Mörtberg and Wallentinus 2000; Snep et al. 2006).

Urban green spaces support biodiversity but also positively contribute to the quality of the urban environment by providing urban residents sites for recreation and experiencing nature. Furthermore, urban residents appreciate urban green space as somewhere to recuperate from both physical and psychological stress (Tzoulas et al. 2007). These benefits of urban green spaces also enhance the value of properties (Luttik 2000). However, maintenance of the urban green infrastructure for the residents and biodiversity in the face of increasing population and expanding cities requires that ecological knowledge be improved and better integrated into social science research and ultimately into urban planning (Breuste 2004, 2008). This integration of ecology and social sciences can be done using landscape ecology as a framework. The above-mentioned ecological approaches represent the "science" of urban landscape ecology which views cities as spatially heterogeneous landscape composed of multiple interacting patches within and beyond the city limits (Wu 2008). However, landscape ecology also includes the "art" component, i.e., the humanistic and social science perspectives necessary for integrating ecology, socioeconomics, design, planning, and management. Thus, the "science" and "art" of landscape ecology provides an appropriate framework for studying the links between ecology and humans in cities by promoting interdisciplinary and transdisciplinary approaches. This is vital for research to provide understanding for urban sustainability (Wu 2008).

This special issue of *Landscape Ecology* includes papers presented at the International Association of Landscape Ecology (IALE) World Congress in July 2007 in Ede, the Netherlands. The papers focus on different aspects of urban landscape ecology and discuss the application of its principles in the urban setting. This special issue provides an excellent view on current issues in urban landscape ecology highlighting research from various parts of the globe.

One of the current issues in urban landscape ecology is the application of the gradient approach in cities. In this special issue McDonnell and Hahs reviewed 300 papers investigating urbanization gradients. Most of the papers investigated the distribution of organisms along such gradients, while only five papers addressed the measures used to quantify the gradient itself. Half of the papers addressing the distribution of organisms investigated the responses of birds to urbanization gradients, while other taxa were less well represented in the studies. The studies utilized a variety of measures of urbanization, but future advances in the field will require the development of some standardized measures to facilitate comparisons between cities. Blair and Johnson investigated the occurrence of birds along urbanization gradients and the key role of sub-urban habitats as entry point for invasive bird species into urban systems and as point of extirpation for woodland species. They also point out that biotic homogenization is more prevalent in cities than in the countryside. Croci et al. showed along urbanization gradients that urban woodlands can be potential sites for biodiversity conservation. They also demonstrate that taxa differ in their response to urbanization and fragmentation. The gradient approach was also used by Pouyat et al. to study the chemical properties of forest soils in three metropolitan areas on two continents. They showed that soil properties vary with various measures of urban land use, including distance to the urban core. Vallet et al. use the gradient approach to compare the effects of urbanization on woodland plant assemblages in two cities and describe species responses by using several indicators. Overall, the different human impacts—urbanization, age of woodland, and hedge habitat—seems to select the same species.

The effect of patchiness of urban habitats (ponds) was investigated by Gledhill et al. who showed that there is a highly significant correlation between pond density and species richness. In his paper, Millard investigated semi-natural vegetation and its relationship to designated urban green space. He showed that numbers of native species correlate positively with areas of green space of high nature conservation value. Neophytes and casuals correlated positively with semi-natural green space. It has been shown that urban areas are prone to invasion by exotic species. Cillier et al. address this issue by studying exotic plant species invasion patterns in native grassland patches surrounded by urban and rural landscapes. They compare results from two continents (South Africa and Australia). Two distinct patterns of exotic species invasion were identified, namely invasion from the edge where the cover of exotic species increased with increasing proximity to the edge, and a pattern suggesting that gap phase vegetation dynamics may drive exotic species invasion at urban grasslands.

Modeling is an approach to assist planning and decision-making. Hepinstall et al. describe an integrated modeling approach to predict the effects of future urban development and land cover change on avian abundance and diversity. Results indicate that landscape composition and configuration are important in explaining land cover change and avian species response to landscape change. Snep and Ottburg develop a planning and design strategy—the 'habitat backbone'—with which to support the long-term survival of pioneer species that occur in ports and have low dispersal abilities. They conclude that a network of patches at (semi-) public land, defined as the 'backbone', with an overall carrying capacity sufficient to support persistent populations, can protect species such as the natterjack toad (*Bufo calamita*) in dynamic port environments.

Papers in this special issue demonstrate that methods and principles of landscape ecology can be successfully used in studying urban ecosystems. The papers also emphasize that urban ecosystems are highly complex, and more complex than many more natural ecosystems. The main difference between urban and non-urban ecosystems is the kind, intensity and frequency of anthropogenic influences. Urban ecosystems are governed by human actions, and it is important to consider these actions when studying urban ecology. The papers in the special issue demonstrate ways in which human interventions can be included in ecological studies and how ecological studies can provide a basis for urban planning for the benefit of urban residents and biodiversity. The papers also show that the understanding of urban ecosystems is incomplete and deserves more research input. At least the following key topics for future research emerge from the papers of this special issue:

1. definition of general principles and concepts of urban landscape ecology;
2. the impact of biotic and abiotic conditions on plant and animal diversity in cities;
3. the role of urban plant and animal species as indicators of the quality of urban nature;
4. development of (landscape) ecological models applicable in urban environments;
5. understanding of urban land use/cover development;
6. conservation concepts for urban biodiversity;

7. integration of ecology and humanities/social sciences into interdisciplinary and transdisciplinary research programmes and
8. integration of urban ecological knowledge into recommendations for urban planning, design, and management.

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