## Abstract

Within contemporary nature conservation there is a growing awareness of the necessity to include landscapes that are intensively used by humans, such as cities. However, since urban landscapes represent different social and ecological characteristics compared to, for example, rural landscapes, the implementation of nature conservation frameworks is not straightforward. Issues of where, what, how and for whom to preserve nature, need to be reconsidered on the basis of the urban context.

This licentiate thesis identifies and discusses these challenges of urban nature conservation. The theoretical framework is based on ideas and methodology from natural resource management, landscape ecology and conservation biology. All of them include large scale approaches to land use policies that to various degrees are applied in research and management of urban systems. This thesis is based on two empirical studies that used a local and a regional/national viewpoint, respectively, and were performed in southern Sweden. **Paper 1** aimed to examine potential differences in nature conservation patterns in relation to various degrees of urbanisation at a municipal level. The number, size, age, land cover and purpose of appointment of 1869 nature reserves in 209 municipalities in southern Sweden were analysed. The analyses showed that the urban nature reserves were fewer and larger, contained a higher diversity of land covers and were founded upon more and more socially oriented purposes of appointment. The found patterns are probably unintended consequences when applying nature conservation practices without recognising the urban landscape characteristics and prerequisites. Consequently, contemporary urban nature conservation planning in southern Sweden mainly protect remains of nature from the urban landscape in which it is embedded, instead of using a more integrative and holistic approach. **Paper 2** was performed at the local scale and studied how spatial, temporal and functional scales were handled within the management of five urban green areas in Greater Stockholm Metropolitan Area, Sweden. The study was based on qualitative data from management documentation and interviews with managers. The combined dataset was analysed by using scientifically defined criteria of ecosystem management. The analyses showed a general awareness of the importance of management at multiple scales, whilst a limited recognition of cross-scale dynamics. This mismatch indicated a view of the urban green areas as temporally static and spatially isolated entities within the urban landscape.

In conclusion the challenges of current urban nature conservation, found in the two studies, can be described as a general mismatch between the natural dynamics and the social demands and management organisation. A more integrated and holistic planning and management of the whole urban landscape is thus necessary to mitigate the ongoing process of degradation of the urban systems.

## Table of contents



## List of papers

**Paper 1:**
Borgström, S.T. Nature conservation patterns in Swedish urban landscapes. Manuscript.

**Paper 2:**
Borgström, S. T., T. Elmqvist, P. Angelstam, and C. Alfsen-Norodom. 2006. Scale mismatches in management of urban landscapes. *Ecology and Society* **11**(2): 16. [online] URL: http://www.ecologyandsociety.org/vol11/iss2/art16/

# Introduction

In a world increasingly dominated by humans (Vitousek et al. 1997, Steffen et al. 2005), protecting "pristine nature" from human threats as the only strategy for nature conservation is more and more questioned (Pimentel and Stachow 1992, Margules and Pressey 2000). There is a growing awareness that contemporary nature conservation also must include ecosystems that are more intensively used by humans (Margules and Pressey 2000, Schwartz et al. 2002, Ricketts and Imhoff 2003, IUCN 2005). Human well-being rests upon functioning ecosystems that provide ecosystem services, such as production of food and fibres, erosion control, decomposition of organic matter and room for recreation (Daily 1997, Millennium Ecosystem Assessment 2005). These ecosystems are built up by biodiversity at genetic, species and landscape levels. From this viewpoint nature conservation becomes tightly linked to socially, economically and ecologically sustainable development from local to global scales (IUCN 2005, Millennium Ecosystem Assessment 2005).

Cities are examples of systems that are characterised by human domination compared to other systems. Nature conservation in urban environments, where most peoples live their lives, is increasingly becoming recognised both in science and in policy (Miller and Hobbs 2002, IUCN 2003, Dunn et al. 2006). However, implementation of general nature conservation policies and practices in urban systems is not straightforward. The main assumptions in this thesis are that urban systems are different from other systems and that the special urban characteristics create new challenges for nature conservation. Basic problems, such as what, where, how and for whom to preserve nature, need therefore to be reconsidered in the urban context.

## Objectives and structure of thesis

Recognition of interactions across spatial and temporal scales is a necessity when analysing open systems such as cities (e.g. Folke et al. 1997, Lovett et al. 2005). Therefore, the two studies included in this thesis analysed the urban landscape at different scales, the local and the regional/national. In order to identify and describe the new challenges of urban nature conservation, following objectives were addressed:

1) Are formally protected areas different, with regard to spatial configuration, age, land cover composition and purposes of appointment, in urban landscapes in comparison to protected areas in less urbanised landscapes? (paper 1)
2) Are mismatches of social and ecological scales more prevalent in urban landscapes? (paper 2)

The thesis starts with a presentation of the theoretical framework that forms the basis for research questions and interpretation of results. Then, using the theoretical framework, the assumption that urban systems are different to other systems is motivated. The methodology used in the studies is presented and the two papers are summarised. Finally, the findings are synthesised and discussed in relation to urban system characteristics. Three characteristics are considered: 1) the high social and ecological heterogeneity, 2) the high frequencies of human induced disturbances and the large proportion of land uses inhibiting natural dynamics and 3) the high competition for land, meaning that urban nature often must harbour multiple and sometimes conflicting values. To conclude, challenges of urban nature conservation are identified and future research presented. In this thesis urban nature conservation includes all stages from planning to managing urban green structures at several spatial and temporal scales.

# Theoretical framework

## Urban studies require research across disciplines

There is a current increase in integrative research (sensu Tress et al. 2005) that is partly due to the inability of specialized science to solve applied societal problems, such as environmental challenges. Research that bridges over disciplines is also an important strategy for addressing phenomena where holistic perspectives are necessary (Tress et al. 2005).

In 1935 Tansley defined ecosystems as "any piece of earth that consists of interacting biotic and abiotic elements that also interacts with the surroundings" (Tansley 1935). According to this definition, cities can be said to be ecosystems, where man is the dominant species (Grimm et al. 2000, McIntyre et al. 2000). During the 1990s, urban ecology challenged the more traditional ecological research by describing cities as ecosystems (Grove and Burch 1997, Niemela 1999, Collins et al. 2000). Several authors suggested various types of social-ecological models and mixtures of methods for analysing urban systems (e.g. Grove and Burch 1997, Grimm et al. 2000, Pickett et al. 2001, Alberti et al. 2003). This thesis can be described as interdisciplinary (sensu Tress et al. 2005) because the studies address a specific phenomenon by using several disciplinary approaches and methods.

## Three disciplines

*Large scale approaches …*

The theoretical foundation of this thesis is primarily built on theories from natural resource management, but is also influenced by landscape ecology and conservation biology. These three scientific disciplines have in common that they include theories and methods that address nature conservation at broader scales and to varying degree include social aspects in the analysis. Examples are regional representation analysis within conservation biology (Margules and Pressey 2000), green networks with cores, corridors and buffer zones at a landscape scale within landscape ecology (Margules et al. 1994, Noss and Cooperrider 1994, Jongman 1995, Ferrier 2002) and ecosystem management within natural resource management (Slocombe 1993, Dale et al. 2000, Bengtsson et al. 2003). The links between these disciplines are further discussed by others (e.g. Poiani et al. 2000, Gutzwiller 2002, Liu and Taylor 2002, Turner 2005, Lindenmayer 2008). Although, urban issues are recognised within these disciplines, their application to cities is still a challenge since they have been developed in other kinds of systems. In this thesis, I most often refer to cities as systems, but where I specifically address urban spatial patterns and processes the concept landscape is used. In literature, the use of these concepts varies depending on discipline and epistemological contexts (e.g. Forman 1995, Liu and Taylor 2002, Pedroli et al. 2006).

*... in urban studies*

In natural resource management research, social and ecological aspects are tightly coupled and studied systems are often referred to as linked social-ecological systems (Berkes and Folke 1998). A typical example is fisheries, where organisation of fishing activities interacts with fish populations. Social-ecological systems are open and highly complex, involving multiple scales in time and space. This complexity makes them dynamic and unpredictable, but with a capacity to adapt to changes (Levin 1999, Scheffer

and Carpenter 2003). Cities are dominated by human activities, where ecological processes are largely driven by social dynamics, e.g. Grimm et al. (2000). Therefore, the model of coupled social-ecological systems is useful for studying urban systems (Grove and Burch 1997, Pickett et al. 1997, Zipperer et al. 2000, Pickett et al. 2001, Alberti et al. 2003).

Increased knowledge of ecosystem complexity has required a broadening of the meaning of "natural resources" to include all goods and services that nature provides the human enterprise, i.e. ecosystem services (Daily 1997, de Groot et al. 2002). The ecosystem service concept is useful in discussions on natures' value in human dominated systems, such as cities, since it is anthropocentric and utilitarian. Current environmental challenges at local to global scales can be described as decline in ecosystems' capacity to provide necessary ecosystem services. One of the major causes for this decline in ecosystem services is a mismatch between social and ecological scales in management (Holling and Meffe 1996, Folke et al. 1998, Young 2002, Cumming 2006, Paper 2). For example, incomplete knowledge of ecosystem dynamics (e.g. disturbance regimes) and institutional constraints (e.g. land-ownership) might lead to management frameworks that ignore ecological patterns and processes (Savard et al. 2000, Saunders and Briggs 2002).

Natural resource management in urban landscapes means land use planning (Zipperer et al. 2000) and one important task is to mitigate fragmentation of remains of nature at a landscape level (Schwartz 1997a, Marzluff and Ewing 2001). When considering optimal configurations of urban nature within land use planning, both conservation biology methods (e.g. population viability analyses) and landscape ecology theories (e.g. island biogeography and metapopulation) are used (Ahern 1999, Kingsland 2002). So far, the major tasks for urban nature management is to identify and preserve as large areas as possible and/or increase connectivity between isolated patches (e.g. Ahern 1995, Schwartz 1997b, Hidding and Teunissen 2002, Marzluff 2002, Stenhouse 2004). Since conservation biology and landscape ecology constitute the dominating scientific foundation of contemporary urban nature management within land use planning, these are necessary parts of any urban system analysis.

## Urban systems are different

*What is urban?*

Defining the unit of study is crucial in all research. However, defining what is urban is often difficult. Urban patterns are strongly linked to the process of urbanisation and there is no general definition of urbanisation either as a pattern or as a process (McGranahan and Marcotullio 2005). One starting point is that "urban" is an agglomeration of human settlement (UN 2004). That could be nearly any occupation of land, spanning over a gradient from cities at one end to rural areas at the other. A city is then an agglomeration of human settlements of a certain size. However, the UN (2004) states that "it is not always straightforward to divide the inhabited territory into urban and rural areas". For example, the lower limit for characterizing an area as urban varies between 200 and 50,000 inhabitants among different countries (UN 2004). In addition, measurements of urbanisation are diverse, e.g. percentage impervious land cover, population density and cultural practices. Thus, it is important to be careful when interpreting urbanisation statistics (Cohen 2004). Urbanisation is a complex process driven by different internal and external drivers, resulting in a diversity of urban patterns world-wide (McGranahan and Marcotullio 2005). Two examples are; growth of slums in

low-income regions where the cities are not prepared to absorb the massive rural immigration (Cohen 2004) and sprawl of cities in high-income regions, where urbanisation primarily is consumption of land instead of increased population density (Chin 2002, European Environment Agency 2006). The urbanisation process is not new, but there are five features that makes current urbanisation different from the earlier: 1) the unprecedented scale, 2) the rapid pace, 3) the occurrence in countries of low per capita income, 4) the dependence of global economy and 5) the convergence in urban and rural life-styles (Cohen 2004). All these make urbanisation a major process of global change that reaches far beyond the cities' physical limits. Furthermore, urban systems constitute the future habitation for the majority of the global population.

*A social-ecological system view on cities*

Cities attract people since they constitute melting pots of cultures, creativity and innovation and are places where power and economy often become centred. The high concentration of humans creates a system that is both socially and ecologically different from other systems (Alberti 2005). Most of the dynamics in urban systems are driven by humans. Besides general social processes, such as information flow, culture and institutions (Grimm et al. 2000), other important social aspects of the urban dynamics are diversity of land-uses, land use intensity and historical context (Dow 2000) as well as levels of income and types of buildings (Hope et al. 2003). This social heterogeneity results in a mosaic of small patches of contrasting land covers (Pickett et al. 1997, Pickett et al. 2001, Berling-Wolff and Wu 2004). The high proportion of built-up areas, with impervious surfaces and constructions, also means that the majority of urban land is locked into land-uses influencing many ecological processes, such as biogeochemical flows of water and nutrients. Urban nature is fragmented. City parks, gardens, golf-courses and urban woodlands constitute small patches in a matrix that usually is very hostile (Kinzig 2001). Frequent land fillings, new constructions and abandonment of patches are examples of land use changes that lead to various ecological disturbances (Rebele 1994, Collins et al. 2000). These urban system characteristics have been suggested to reinforce mismatches of social and ecological scales (Borgström et al. 2006).

The intensive use of resources causes local urban environmental problems since it has an impact on local climate, hydrological processes and biology (Botkin and Beveridge 1997, Kendle and Forbes 1997, McDonnell et al. 1997, Kinzig 2001, Pickett et al. 2001, Whitford et al. 2001). Many cities therefore represent unhealthy environments for humans (UN 2004). However, there is a growing awareness of the connection between citizen's well-being and access to urban green areas (Ulrich 1991, Takano et al. 2002, Stigsdotter 2005, Tzoulas et al. 2007). Many urban environmental problems, such as air pollution and noise, could be mitigated by urban green structures (Beckett et al. 1998, Bolund and Hunhammar 1999, Jansson and Nohrstedt 2001, Chiesura 2004, Yang et al. 2005). This is a new view of urban nature: to be seen as a necessity, and not just something important just for conservationists or a luxury in wealthy neighbourhoods.

*Urban nature characteristics*

Cities have traditionally been seen as opposite to nature both in research and policy. Still, most urban landscapes consists of many kinds of urban nature, city parks, public and private gardens, urban woodlands, agricultural fields, protected areas, cemeteries, sports fields, flower beds, green roofs and road verges (Kendle and Forbes 1997). Each patch is usually used for several purposes, for example being "a calm, silent oasis", "a playing ground", "an exercise area", " a particle and noise filter", "an architectural object" and "a

refuge for biodiversity". This is a potential source of user conflicts, especially where the patches are small and isolated in areas dominated by other urban land uses. Many of the ecosystem services provided by urban nature are also indirect and therefore difficult to measure and evaluate. Within comprehensive urban land use planning, the different urban green structures are often grouped into a coarse class of "non-exploited land" as opposite to exploited land. At a local scale, on the other hand, the green structures are instead divided into sub-groups by kind of usage, e.g. cemeteries constitute one group (Colding et al. 2006, Colding 2007, Barthel et al. 2008). These administrative patterns are practical examples of the urban social heterogeneity.

Both the unawareness of urban nature as provider of important ecosystem services and the administrative divisions conceal the value of urban nature, which seldom is accounted for when exploitations are assessed. To counteract this common neglect, current urban nature conservation includes creation and management of regional green structures and nature reserves, as well as city parks, gardens and cemeteries (Kendle and Forbes 1997). However, nature conservation practices are often developed in more rural systems and may therefore lead to unintended and even negative consequences, if urban system characteristics are not acknowledged (paper 1, 2).

## Summary of papers

### Study area and methods

*The Swedish context*

The studies in this thesis have been performed in Sweden, where 85 per cent of the population is living in urban landscapes (Statistics Sweden 2006). Though Sweden is highly urbanised, with a population density of 1444 pers/km$^2$ in urban regions, the average population density is only 20 pers/km$^2$ (Statistics Sweden 2006). The major urbanisation took place during the mid-1900s, and today the Swedish cities are growing slowly. The dominating urban planning strategy is compaction. Gaps in the built up areas are exploited to enable larger patches of nature to be left outside these condensed city cores and also to decrease segregation between different neighbourhoods (Boverket 1994, Ståhle 2005). However, many Swedish cities experience sprawling developments (Arnstberg 2003). The total area of urban nature is decreasing (Statistics Sweden 1993), and the main governmental response is to require extended municipal green structure planning (SEPA 2004) and programs for creation of new protected areas (Regeringskansliet 2002). Urban studies in Sweden is internationally relevant due to a long planning tradition, starting in the early 19$^{th}$ century (Rudberg 1999). Thus, long records of different planning strategies and their consequences are available to improve the understanding of urban dynamics. Furthermore, many Swedish cities were founded more than 1000 years ago (Åström 1993) and have been spared from war damages that have reshaped many other European cities.

Sweden covers 1600 km in N-S direction (55-69° N, 11-24° E) and there are large differences in physical constraints on land use and hence urbanisation within the country. Therefore, paper 1 was delimited to southern Sweden, which has 84 per cent of the population and covers 32 per cent of the total Swedish land area (figure 1a). This study used a classification of land developed by the Swedish Rural Development Agency (2007), where "urban land" is defined as a population centre with more than 3000 inhabitants and includes a zone within 5 minutes travelling distance (by car) from that

population centre. A Swedish population centre is defined as an area with more than 200 inhabitants and 200 m between the buildings at the most (Statistics Sweden 2006). I have calculated the share of urban land for each municipality included in the study, here referred to as the municipal degree of urbanisation. Paper 2 focused on the local level of practical management and was performed in Greater Stockholm Metropolitan Area (figure 1b, c). This is the most urbanized region in Sweden with 2500 inhabitants/km$^2$ (Statistics Sweden 2002). Current green area management and planning is challenged by the forecasted population growth, which is estimated to approximately 20.000 new inhabitants per year (Regonplane- och trafikkontoret 2001). Meanwhile, the program for protecting urban green areas includes creation of 71 new nature reserves until 2013 (Länsstyrelsen i Stockholms län 2003).

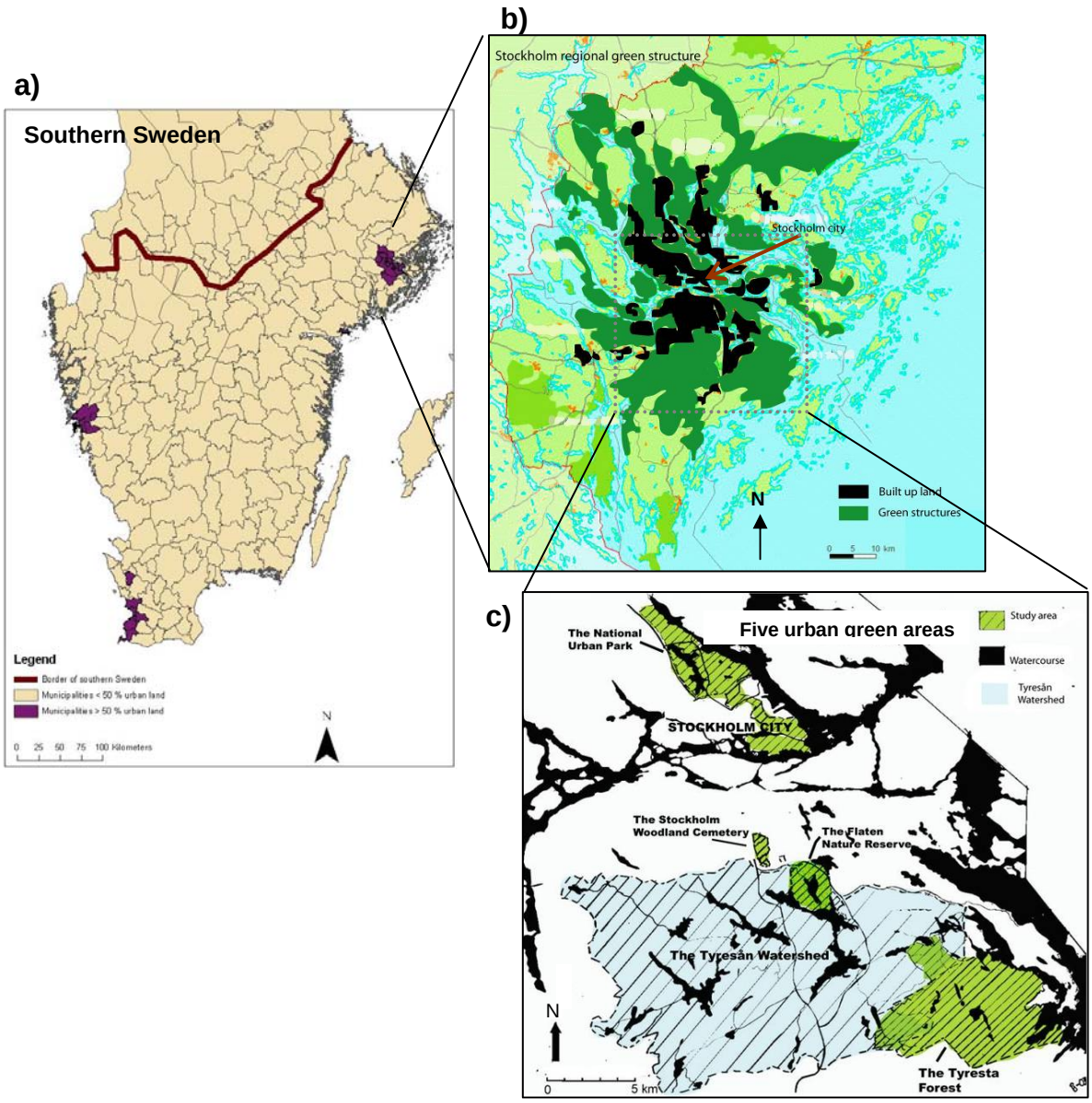


*Figure 1: Maps of study areas: a) Southern Sweden (paper 1), b) Greater Stockholm Metropolitan Area (paper 2) and c) the five different green areas included in paper 2.*

*Research questions and methodology*

Urban studies display a large palette of methods and a few of these are used in this thesis. I have used different viewpoints in the two studies and hence applied different methodologies. Both studies were based on empirical data, but the analyses were quantitative and qualitative, respectively.

In the first study (paper 1), formal nature conservation patterns in landscapes with different degrees of urbanisation, was analysed quantitatively. It was based on secondary data in 1869 nature reserves in 209 municipalities in southern Sweden (figure 1a). The following research questions were addressed; First, what, if any, are the differences in nature conservation patterns, nature reserve size, age, land cover composition and purpose of appointment, when comparing urban landscapes to rural landscapes? Second, how are these differences related to general urban landscape characteristics? Third, based on the revealed pattern of urban nature conservation, what are the future challenges? The relationships between different variables describing the nature reserves' characteristics and the degree of urbanisation in the surrounding landscape were statistically analysed.

The second study (paper 2) focused on the local level of practical management and aimed to investigate how different spatial, temporal and functional scales were dealt with in management of five different urban green areas in Greater Stockholm Metropolitan Area (figure 1). The following research questions were addressed; First, do current management practices recognise temporal and spatial scales in management? Second, do current management practices recognise the complexity, interconnectedness and dynamic characteristics of ecological systems? Third, what strategies are currently feasible for reducing mismatches in urban landscapes? These questions were examined through the compilation of a combined, qualitative dataset of management documentation dating 10 years in back in time and interviews of formal managers. To enable a social-ecological evaluation of management of scales, the theoretical frameworks of ecosystem management (Christensen et al. 1996) and hierarchical planning (Angelstam et al. 2003, Angelstam et al. 2005) was applied.

## Results

*Paper 1 - Nature conservation patterns in Swedish urban landscapes*

The analyses showed that urban nature reserves were fewer and larger than nature reserves in rural landscapes. They also contained a higher diversity of land covers and were founded upon a larger number and more socially oriented purposes. Furthermore, similar urbanisation induced changes of land cover composition were found both in the municipalities and in the nature reserves.

The pattern of few but large nature reserves might indicate that urban nature is preserved at the periphery of the city, where more nature is still available. This plausible pattern could not be tested since data on the geographical distribution of the nature reserves was not available. Large nature reserves have potentially higher diversity of biotopes and therefore probably provide more ecosystem services (Hooper et al. 2005), but see (Kremen 2005). Large nature reserves might also be able to mitigate urban problems such as user conflicts and wear from high visitor frequencies, which are typical urban problems. However, the few nature reserves in urban landscapes might be isolated with large both structural and functional distances between them, and to other types of urban green structures. This can be detrimental for biodiversity (Drayton and Primack 1996,

Woodroffe and Ginsberg 1998, Marzluff and Ewing 2001) and social values (Berggren-Bärring and Grahn 1995, Hörnsten 2000, Ståhle 2005) and thereby counteract the purposes of nature conservation.

The land cover composition in a landscape generally changes because of urbanisation. Similar changes in land cover composition were found both in municipalities and nature reserves. Forests and wetlands area decreased and agricultural land area increased with increased urbanisation at the municipal level. For some land cover types the over/underrepresentation in the nature reserves were enhanced with increased urbanisation. One suggested explanation was that general nature conservation prioritisations are applied in the urban landscape that have an originally different land cover composition compared to rural landscapes. If a land cover type in an urban landscape is perfectly represented in the protected areas, this might be insufficient for ecological functionality because the overall proportion in the landscape is too small. The results therefore call for carefulness in the use of representation analyses in urban nature conservation planning.

Urban nature reserves were founded upon more purposes than rural ones. This might be because of that they are larger, but also that a combination of many values gives strong incentives for protection, particularly where competition for land is high. Socially oriented purposes, such as outdoor recreation and cultural history, dominated in urban nature reserves. One plausible explanation to this association is the former land uses (Foster et al. 2003), such as agricultural activities and creation of areas for out-door recreation as part of urban development. Even if socially defined ecosystem services are more useful to gain public support, a strong social orientation of urban nature conservation risks to compromise ecological processes and patterns. These are of importance also for the social values in a long term perspective. Purposes of restoration and creation were not as prominent as expected in urban nature reserves. The high land use pressures seem to strengthen the legacy of threat initiated nature conservation, and limit the abilities to secure potential values in many restoration site in urban landscapes.

The main challenge to future urban nature conservation revealed in the study was to develop strategies that are integrated into the urban context, e.g. the land use history, the land cover proportions, the current dominance of social purposes and the high exploitation pressure.

*Paper 2 - Scale mismatches in management of urban landscapes*

Management within green areas was usually divided into certain subgroups after land cover type, e.g. meadows or lakes. However, the ecological connections between these were seldom recognized, e.g. water flowing from a meadow to a lake. Furthermore, the regional green structure was usually mentioned in management documents, but in practical management communication between stakeholders in neighbouring areas was rare. Analyses of temporal scales showed that long-term visions had recently been incorporated into the management plans, but with limited connections to annual planning and daily practices. Both the regional authorities and the municipalities had land use plans stretching more than 10 years ahead, while the practical management was planned annually. Within the studied areas, there was a recent recognition of ecosystem dynamics, but usually on a very local scale, e.g. biotopes. However, social values in the areas were commonly prioritised before ecological dynamics. The potential cross-scale dynamics were generally unattended both within and between the green areas.

The study showed that there was a general awareness of the importance of management at multiple scales, but only a very limited recognition of interactions across scales, indicating a lack of knowledge of ecosystem dynamics at larger scales. The management activities seemed to be disconnected from the surrounding landscape, generating plans incapable of bridging long-term and short-term goals. This mismatch of scales indicated a view of Stockholm's urban green areas as temporally static and spatially isolated entities within the urban landscape. One plausible reason for the neglect of cross-scale interactions might be the often unattended meso-scale that has the potential to connect local and regional management and short-term and long-term planning (figure 2). One effect of the neglect of ecological cross-scale interactions in the generally highly fragmented urban landscapes is an erosion of the ecosystem capacity to provide ecosystem services. Using a natural resource management perspective, suggested strategies for overcoming urban scale mismatches were: 1) development of an integrative view of the whole urban social–ecological landscape, and 2) creation of adaptive governance systems to support practical management.

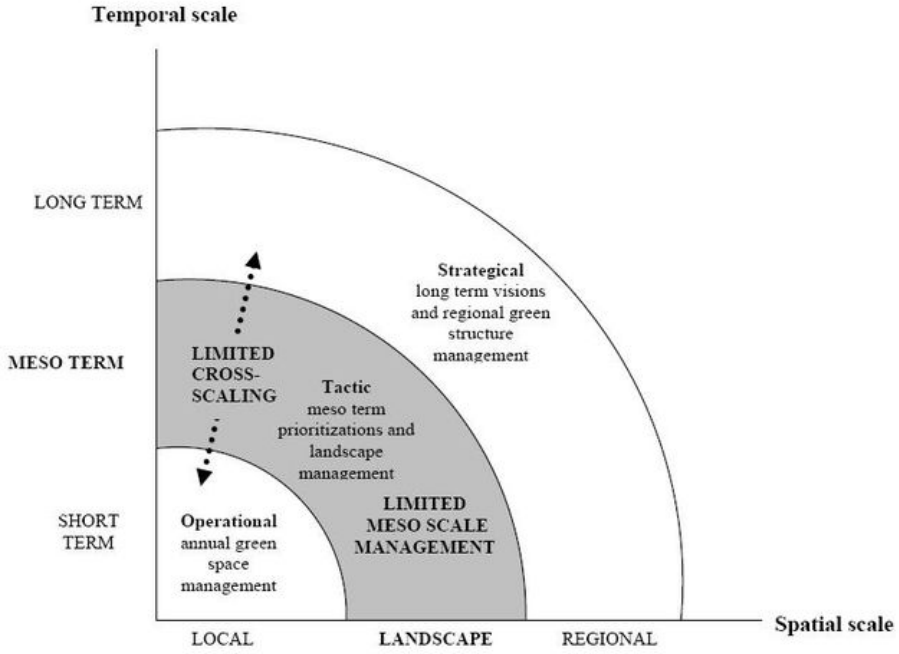


*Figure 2. A schematic picture of the scale management viewed from the perspective of local, practical management of urban green areas in Greater Stockholm Metropolitan Region (paper 2). One suggested source of the found limited cross-scaling is the neglect of spatial and temporal meso-scales.*

## Challenges of urban nature conservation

### The urban context of heterogeneity, disturbances and land scarcity

Three major characteristics of urban systems are recognised and discussed: 1) the high social and ecological heterogeneity 2) the high frequencies of human induced disturbances and the large proportion of land uses inhibiting ecological processes and 3) the high competition for land, meaning that urban nature often inhabit multiple and sometimes conflicting values.

The urban heterogeneity is scale dependent (Band et al. 2005, Andersson et al. 2007). Viewed at a large, regional perspective, the urban landscape contains relatively small patches that often are very different. Therefore, one might assume that this would result in small urban nature reserves. But on the contrary, one important result from paper 1 is that urban nature reserves are larger than reserves in more rural landscapes. The spatial heterogeneity, measured as different land cover types, does not seem to determine the size of protected areas. If urban green structures are delimited independently of the landscape heterogeneity it means that a high degree of heterogeneity might be found within each green structure. This enhances the number of potential values that may exist per area unit and explains the higher diversity of land covers in urban nature reserves (paper 1). Furthermore, the high heterogeneity within green areas probably also account for many ecological and social values. One important challenge for urban nature conservation is therefore to identify and manage the sources of heterogeneity to enable preservation of ecological and social values.

One aspect of urban landscape heterogeneity is that it might influence the effective distances in the landscape. Besides spatial distance, effective distance includes a qualitative aspect of permeability, where landscape content and configuration impacts organism dispersal (e.g. Taylor et al. 1993, Ricketts 2001, Goodwin and Fahrig 2002). If two habitats are divided by a landscape with many different land uses, as in cities, this might complicate migrations for example. On the other hand, a high heterogeneity might also decrease the effective distance depending on what organisms' preferences are. This aspect of urban heterogeneity is important when discussing green corridors, which is a common urban nature conservation activity (e.g. Marzluff and Ewing 2001, Chetkiewicz et al. 2006). The design and management of corridors must be considered in relation to how it is supposed to link urban green areas in an inherently heterogenic landscape.

From a management perspective, urban heterogeneity seems to increase isolation of urban green areas. Even if ecological connections exist they are not obvious to the mangers (paper 2). Examples are: runoff water that connects terrestrial land to open water within a watershed, or migration of pollinators between flowering plants in cemeteries surrounded by private gardens. Land and water, or the cemetery and private gardens, are perceived as different both socially and ecologically, even if they are ecologically connected. Also within urban green areas, the biotopes are often managed separately due to administrative divisions that ignore ecological connections (paper 2).

Buffer zones can be especially important in urban landscapes where human induced disturbances, such as air pollution and change of local climate, are common (Kendle and Forbes 1997). Another function of buffer zones can be to mitigate the wear of visitors in ecologically sensitive core areas. Large sized nature reserves enable a diversified land use planning that can include buffer zones (paper 1). However, in the management study, only one green area used this kind of strategy and it was the most remote area within the study (paper 2). The impact from the surrounding landscape, which can be severe in parts of urban environments, seemed not to be acknowledged. This refers back to the reasoning about urban heterogeneity above.

Natural dynamics and changes are necessary parts of ecosystem functioning (Levin 2000, Scheffer 2001). Such dynamics, for example water level variations or forest fires, were often restricted in management of urban green areas (paper 2). The large sized nature reserves can theoretically allow for large scale disturbances and changes. Meanwhile, the

dominating purposes of both the urban nature reserves and other green areas were socially oriented, and thereby natural dynamics was often not prioritised (paper 1, 2). Another cause to the limited recognition of natural dynamics was the organisation of urban nature management into smaller units (e.g. biotopes), and ignorance of connections to neighbouring land uses. Large scale dynamics needs a landscape perspective where different land use patches can complement each other, and time frames that connect annual management to long term visions. This is challenging in urban landscapes due to the social and ecological heterogeneity.

Both studies found that urban green areas are to a large degree founded on or managed for socially oriented values. In planning of nature reserves, the social orientation might be a way to facilitate an appointment process by selecting areas where nature values can be protected along with already recognized social values. Meanwhile, in green area management, public demands are prioritized at the expense of ecosystem dynamics. Both results can be interpreted as effects of high competition for land, where the justification of nature conservation and management must be supported by the citizens. Another effect of the high degree of land use competition is the focus on protecting remaining values of urban nature from the threats of urbanisation. The challenge is to raise awareness and support for the ecological foundation of all ecosystem services, both socially and ecologically oriented, existing and potential. In case of conflicting goals, such as between developments for recreation and preservation of biodiversity, this might be especially important. Furthermore, this is an issue of where future urban nature conservation is to be located in the urban landscape. If places with overlapping values, or of only socially significance, are prioritised, there is a risk of neglecting ecologically significant areas that are important in the urban landscape.

Taken all together, the urban characteristics discussed here also influence what planning methods are useful in urban nature conservation. One example is the representation analyses that present perfect representations of land cover that are decreasing in the landscape as a whole because of urbanisation. The key issue is then to develop methods that address both these kinds of general land cover changes and ecological and social requirements. Finally, the few urban green areas that have to satisfy multiple user demands and are under stress from human induced disturbances will likely need more intensive management to sustain social and ecological values. One challenge is then how to finance such intensive management when lack of resources is already one important constraint in nature conservation generally (Borgström 2003).

## Conclusions - challenges in the urban context

Urban nature conservation planning and management aims to decrease negative consequences of urban development. However, this thesis acknowledges many difficulties when trying to sustain a viable nature in a human dominated system. All these challenges can be described as a general mismatch between the natural dynamics and the social demands and management organisation. Since the ecological foundation of cities, often is hidden (Pyle 1978, Miller 2005), these mismatches are not surprising. The future urban nature conservation is about bridging those mismatches and integrating urban nature into the urban landscape. The major challenges are:

- To preserve the high diversity of land cover types and values per unit green area originating from the heterogenic former and current land uses.
- To enhance spatial and functional connectivity of green area patches

- To co-ordinate all kinds of urban nature, displaying different management regimes and purposes, to allow for large/long-term scale ecological processes and hence match ecological cross-scale dynamics.
- To secure the capacity to produce ecosystem services and handle future changes.

An increasing amount of resources are devoted to nature conservation in cities all over the world in order to improve the cities' environmental conditions, attract inhabitants and tourists, or to enhance general social, economical and ecological sustainability (IUCN 2003). If the challenges described in this thesis are not recognized, these efforts might just slow down the degradation of urban systems instead of improving the conditions.

## Future research

The two papers in this thesis are snapshots of current patterns and approach the urban system from a local and a regional/national level. The next step is to extend the time frame and start from the landscape level looking at the processes. Since the social and ecological heterogeneity is an important part of the urban landscape characteristics, the processes behind this pattern are keys to preserve current values. Therefore, paper 3 and 4 in my coming thesis will address these processes by dealing with temporal aspects of the urban system (figure 3). These studies are planned to address following questions: What happens in the surrounding landscape when an urban nature patch is assigned as a protected area? and What happens with the local management of green areas when the surroundings are urbanized? These questions are important scientifically and for policy. It is important to enhance knowledge of the matrix between identified patches as a part of landscape ecology research and to continue to evaluate the application of conservation biology in the urban setting. The relevance for policy is to inform ongoing processes where new landscape management tools are emerging or redesigned, for example zoning of different land use in extensive nature conservation areas that may include whole cities.

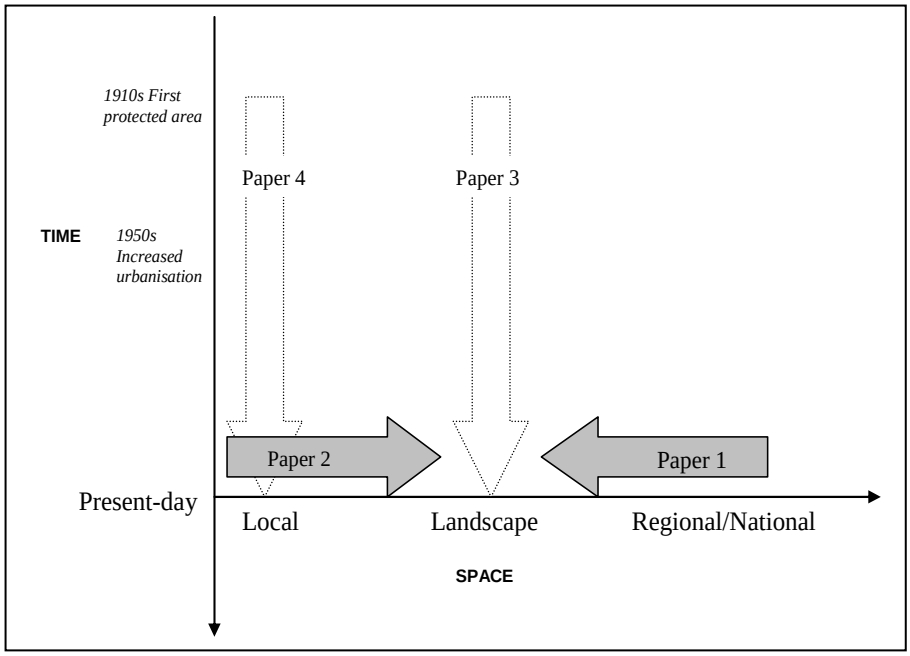


*Figure 3: Outline of the PhD-project and schematic organisation of papers. The focal point in the project is urban patterns and processes from a landscape perspective. Grey/filled arrows are the papers in this thesis and white/dotted-lined arrows are planned papers.*

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