

# Recalling Urban Nature

- linking city people to ecosystem services

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“During the course on interdisciplinary research methods, the professor went for a walk by the lake with her students. She stopped on a meadow in front of a large Aspen, and asked them-*what do you observe?*  
One student quickly responded - *leaves are moving.*  
Another one, who tried to outsmart the first, said- *wind is moving.*  
The third student long gazed at the tree in silence.  
Then he talked. -*Mind is [co-] moving.*”  
(Modified Zen-story)

*To Leo and Rosa-Linn*

## Abstract

People, society and ecosystems are embedded in social-ecological systems, and societal development ultimately is dependent on the generation of ecosystem services (ES) to sustain it. Many ES are degrading however, reflected for instance in the world wide crisis in the pollinator service. Related to this urgent issue, the objective of this thesis is to investigate how actors and actor groups, as well as their governance context, shape the generation of ES. Focusing on social-ecological features behind management practice, the empirical basis are a number of case studies in Stockholm, Sweden, including allotment areas, cemeteries, city parks, as well as a large urban national park. The thesis uses a theoretical lens of complex adaptive systems theory and resilience thinking for the interdisciplinary approach. Methods include ecological inventories of birds and bees and studies of maps, field observations, questionnaires, deep interviews, literature analysis, as well as synthesis writing. It consists of four papers, where results suggest new issues explored in subsequent papers. *Paper I* shows that the urban landscape owes its current flow of ES to co-evolutionary processes and that green governance with the aim of sustaining such ES must take into account historical property and management rights and the involvement of a diversity of actor groups, as well as ecological processes of the larger landscape. *Paper II* studies allotment gardens, cemeteries and city parks in relation to the generation of pollination, seed dispersal and pest regulation. Differences in social mechanisms behind management practice are reflected primarily as higher abundance of pollinators in the informally managed allotment gardens and as differences in the compositions of seed dispersers and insectivores' birds. Thus, voluntary, informal and often ignored actor groups, motivated by sense-of-place, play an important role for the generation of some ES here. *Paper III* shows how local management practice, linked to ES generation, is retained and stored among allotment gardeners, and modified and transmitted through time, by means of social-ecological memory (SE-memory). SE-memory is an emergent property of a dual process of participation and reification in communities of allotment practice. It facilitates monitoring of local change and seems to link practice, often in habits, to place specific processes that underlie prime ES. *Paper IV* explores how spatial scale mismatches between ecological process and processes of management can be bridged by a spatially explicit and flexible social network structure of governance. Policy recommendations for how to strengthen the flow of ES are provided, including appointing mid-scale actors with focus on ecosystem management of the ignored mid-scale, and of scale-crossing brokers with focus on creating relations between disconnected actor groups on multiple spatial scales. Urban ES are a product of complex and human driven co-evolution, consequently sustaining ES in urban landscapes is not about conservation without people, but shaped by and dependent on management practice by people. Practice that links to generation of ES are facilitated by SE-memory of local communities of ecosystem practice of physical sites in the landscape, which also is where meaning and motivation of voluntary management is created. Long term management rights that allow for such qualities to emerge are crucial in this regard. Consequently, local actor groups, which contribute to the production of ES, should explicitly be integrated with green governance of Stockholm, which could be put in practice by facilitating emergence of actor groups engaged in scale crossing brokering that provides collaborative platforms, supports a diversity of actor groups and cultivates features that enable local self-organization.

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## List of papers

- Paper 1      Barthel S., Colding J., Elmqvist T., and Folke C. 2005. History and local management of a biodiversity rich, urban, cultural landscape. *Ecology and Society* **10**:10.
- Paper 2      Andersson, E., Barthel, S. and Ahrné, K. 2007. Measuring social-ecological dynamics behind the generation of ecosystem services. *Ecological Application* 17(5): 1267-1278.
- Paper 3      Barthel S., Folke, C., and Colding J. Social-ecological memory for management of ecosystem services. *Manuscript*
- Paper 4      Ernstson, H., Barthel, S., Andersson, E., and Borgström, S. Ecological scales and social network structure in urban landscapes: management and governance of urban ecosystem services in Stockholm, Sweden. *Manuscript*

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## Swedish Summary/Svensk Sammanfattning

Endast en bråkdel av jordens biologiska mångfald existerar idag inom skyddade områden, den största delen har funnits i ekosystem som är mänskligt förvaltade. Den här avhandlingen handlar om förvaltning, vård och utveckling av biologisk mångfald och ekosystem i stadslandskap. Den undersöker mänskliga aktörer och aktörsgrupper som är engagerade i förvaltning, med fokus på sammanlänkade social-ekologiska processer som möjliggör en förvaltning som är anpassad till dynamiska ekosystem. Ett grundläggande antagande är att civilisation och ekosystem är sammanlänkade i *social-ekologiska system*, och att samhällsutveckling i grunden är beroende av biosfärens kapacitet att möjliggöra den. *Ekosystemtjänster* (ES) är hela frekvensen av tillstånd och processer genom vilka ekosystem möjliggör mänskligt liv, inkluderat provianterande tjänster (t.ex. mat och kläder), reglerande tjänster (t.ex. luft rening och sjukdomsreglering), kulturella tjänster (t.ex. rekreation och estetiska upplevelser), samt stödjande tjänster som underliggör produktionen av alla övriga ES. Slutsatsen av den globala utredningen *Millennium Ecosystem Assessment* var att många av jordens ES är försämrade, reflekterat bland annat i en världsomfattande kris rörande pollinering för odling och för biologisk mångfald. Relaterat detta brådskande faktum är målsättningen för denna avhandling att undersöka hur aktörsgrupper, samt den sociala kontexten av ledning och beslutsfattande som de tillhör, formar genereringen av urbana ES. Den empiriska basen är en rad fallstudier i Stockholms urbana landskap, inkluderat kolonilottsområden, kyrkogårdar, stadsparker samt Nationalstadsparken. Avhandlingen använder en teoretisk lins, bestående av komplexitets teori i kombination med resiliens tänkande, för att analysera information som fångats genom ämnesövergripande metoder. Dessa inbegriper ekologiska inventeringar av fåglar och humlor, studier av historiska och moderna kartor samt biotopkartor, observationer i fält, frågeformulär, djupintervjuer, litteraturstudier och synteser. Avhandlingen består av fyra uppsatser där resultat leder till nya frågor som adresseras i efterföljande uppsatser. **Uppsats I** är en fallstudie av Nationalstadsparken, som är ett stort och centralt beläget grönområde i Stockholm. Den visar att flödet av ES här beror på processer av samevolution mellan människa och ekosystem, och att ledning och beslutsfattande med målet att bevara detta flöde av ES, behöver ta i beräkning historiska äganderätter och förvaltningsrätter, deltagandet av en mångfald av aktörsgrupper, samt processer som sammanlänkar parken med omkringliggande ekosystem. **Uppsats II** studerar kolonilottsträdgårdar, kyrkogårdar och stadsparker i relation till generering av tre ES; pollinering, fröspridning och naturlig skadedjursreglering. Variation i bakomliggande sociala kvaliteter och processer; institutioner, lokal ekologisk kunskap och platskänsla (*sense-of-place*), förklarar skillnader i förvaltningspraxis mellan dessa typer av områden. Dessa skillnader reflekterades i flödet av ES, primärt i en högre abundans av pollinerande humlor i de informellt förvaltade koloniträdgårdarna, och i skillnader i kompositionen av fågelarter som sprider frön i rummet och av fågelarter som äter insekter. Sålunda, frivillig och informell förvaltning motiverad av platskänsla, och ofta undervärderad i dessa sammanhang, spelar en viktig roll för genereringen av ES i detta landskap. **Uppsats III**, fokuserar på kolonilottsodling och bygger på resultat från uppsats två. Uppsatsen frågar sig hur förvaltningspraxis inom självorganiserade grupper, och som stödjer flödet av ES, bevaras och lagras, och hur de modifieras och överförs i tiden.

Svaret utvecklas här genom iden om *social-ekologiskt minne*, vilken är en upplevelse baserad och framväxande egenskap genom deltagandeprocesser och reifikationsprocesser i grupper med gemensam social praktik (*Communities-of-practice*). Exempel på deltagandeprocesser är imitation av kroppsarbete och vardagliga samtal om odling, och reifikations processer kan vara ordspråk, fotografier och fysiska objekt, så som fågelholkar och fruktträd. Social-ekologiskt minne stödjer odlare i övervakningen av lokal förändring och det verkar som om det länkar praxis, ofta genom vanor, till platsspecifika processer som underliggör önskade ES. *Uppsats IV* undersöker hur sådana lokala kvaliteter kan integreras i ledning, förvaltning och beslutsfattande rörande ES i det större stadslandskapet och hur förvaltning kan anpassas till ekologiska processer i rummet. Den fjärde uppsatsen är en syntes av sju fallstudier utförda i Stockholm och som genomförs med en kombination av ett strukturellt nätverksperspektiv och ett skaltänkande baserat på ekologiska processer. Pappret tillhandahåller en linje för hur förvaltningen av ES kan förbättras, genom att införa ett tydligt skaltänkande och genom att öka flexibilitet i styrning så att en förvaltning som är anpassad till dynamiska ekosystem görs möjlig. Detta kan förverkligas genom att främja framväxten av aktörsgrupper med målsättningen att sammanlänka aktörer som idag ignorerar varandra. Denna avhandling hävdar att urbana ES är en produkt av komplexa och aktörsdrivna samevolutions processer, och därför handlar bevarande av ES i stadslandskap inte om skydd *från* människor, utan om hur de är beroende av fortsatt förvaltning *av* människor. Förvaltningspraxis som stödjer ES främjas av social-ekologiskt minne inom lokala grupper som är aktiva i vård och förvaltning i det fysiska landskapet, och det är också här som mening och motivation för frivillig förvaltning skapas. Långtidsavtal rörande förvaltningsrätt som tillåter sådana lokala kvaliteter att växa fram är centralt i detta sammanhang. Sådana skapar incitament för stadsmänniskan att aktivt delta i förvaltningen av ekosystem, aktiviteter som i sin tur kan påverka det allmänna stödet för naturvård och en ekologisk hållbar utveckling. Följaktligen, lokala aktörsgrupper, vilka främjar flödet av ES, bör aktivt tas in vid beslutsfattande och ledning rörande stadens grönområden, exempelvis genom att skapa samverkansarenor där aktörs grupper som idag inte har några relationer kan träffas och lära av varandra. Detta medför utmaningar då grupper med olika intressen möts. En linje om hur det ska förverkligas inkluderar att främja framväxten av skalövergripande medlare (*scale-crossing-brokers*) med målet att föra samman aktörsgrupper som är aktiva inom förvaltning av olika rumsliga skalor, samt är aktiva inom olika samhällsnivåer. Dessa medlare bör verka för att skapa ett socialt nätverk med en mångfald av aktörsgrupper, de bör verka för lokal självorganisering och samtidigt vara uppmärksamma på toppstyrda lösningar och blåkopior vilka tenderar att uppkomma. Decentralisering för självorganisation verkar bygga mångfald och ökad resiliens inför ekologisk förändring och därför bör system av adaptiv styrning och beslutsfattande, med möjlighet att växla mellan toppstyrning och decentralisering, införas vid förvaltning av stadens ekosystem. Upplevelsebaserade kvaliteter hos lokalt verkande aktörsgrupper, så som platskänsla, identitet och mening och social-ekologiskt minne är viktiga komplement till generella ekologiska teorier när vi gemensamt ska verka för en ekologiskt hållbar utveckling på den här planeten.



## Introduction

This thesis is about actor and actor groups in relation to on the ground management of biodiversity and ecosystem services in urban landscapes, with a focus on social-ecological features behind management practice. A dominant proportion of all species live in ecosystems that are managed by humans and only a small fraction of biodiversity exists in protected areas (Pimentel et al. 1992; Hoekstra et al. 2005). The Millennium Ecosystem Assessment concluded that ecosystems of the world are degrading, reflected in a worldwide crisis in many ecosystem services for human wellbeing (MA 2005). Knowledge and understanding of the role of urban landscapes in this context needs to be developed (Grimm et al. 2008). Time is ripe to consider urban landscapes for their potential role in sustaining species richness and for generating ecosystem services (MA 2005; iclei 2008, <http://www.iclei.org/index.php?id=6803>).

This thesis assumes that ecosystems, society and people are embedded in social-ecological systems (SES) (Berkes and Folke 1998) with societal development ultimately being dependent on the life-support capacity of the biosphere to sustain it (Odum 1989). Ecosystem services (Folke 1991; Daily 1997) are generated in SES and they are defined as the conditions and processes through which ecosystems sustain and fulfill human life, including provisioning services (products like food and fiber); regulating services (e.g pest regulation and air filtration); cultural services (e.g spiritual enrichment, recreation, and aesthetic experiences); and supporting services being necessary for generation of all other ecosystem services (MA 2005).

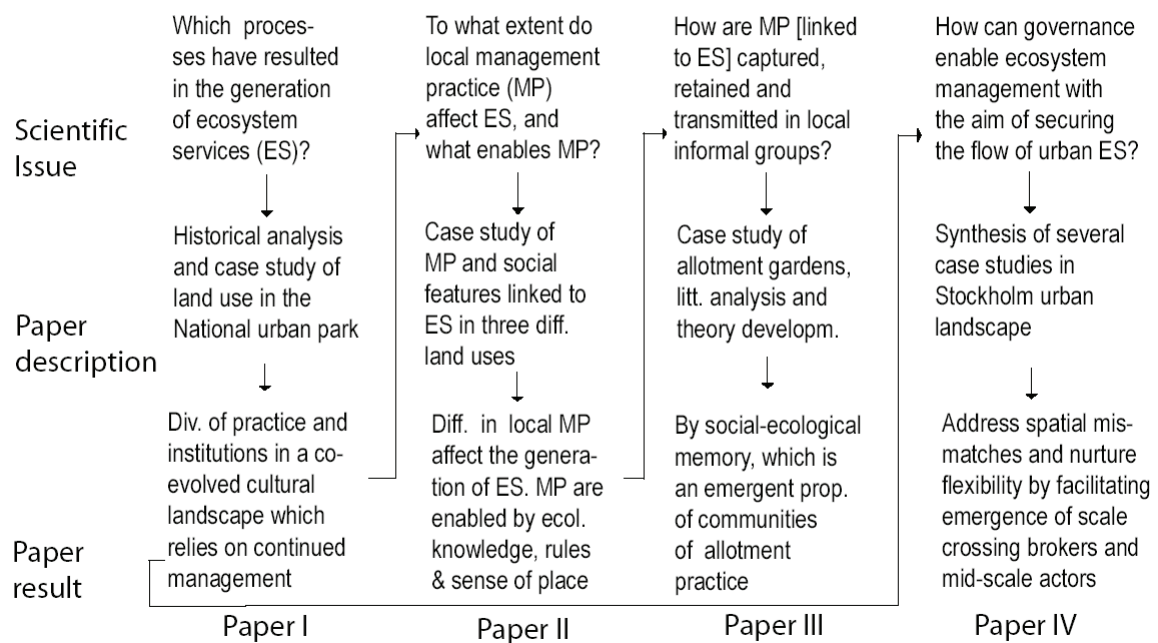
Urbanization is a global trend (UN 2007), and a main driver for the drastic and persistent changes in habitats and landscapes both around and within urban landscapes (Rees 1997; Folke et al. 1997; Alberti et al. 2003; Antrop 2004; McKinney 2006). As more people are projected to live in urban landscapes (UN 2007), the wellbeing of a growing proportion of humanity will depend on urban ecosystems for enjoying services such as recreation, aesthetic experiences, health regulation, as well as services like air filtration, water retention and pollination (Pyle 1978, 1993; Bolund and Hunhammar 1999; Jansson and Nohrstedt 2001; Grahn and Stigsdotter 2003; Chiesura 2004; Takano et al. 2002; Miller 2005).

The purpose of the thesis is to investigate how actors and actor groups as well as their governance contexts shape the generation of ecosystem services in the urban landscape of Stockholm, Sweden. Actors and actor groups are here used as both stakeholders and/or stewards that actively may take part in on-the-ground management of ecosystems, as well as such individuals or groups that may indirectly facilitate or constrain practical management and the generation of ecosystem services. The departure is a study of historical land uses and current “local stewards” (Schultz et al. 2007) of urban green areas and their management rights of the National Urban Park of Stockholm (see Figure 1). Results highlight that biodiversity of this cultural landscape is a reflection of a co-evolutionary process of humans and nature (Norgaard 1994), and that the reasons for the relative rich flow of ecosystem services there, relate to past land use and current management of the land (*Paper I*).

The second section moves on to analyze social-ecological processes behind the generation of three ecosystem services; pollination, seed dispersal and pest regulation. Interdisciplinary studies of three types of intensively managed urban green areas: city parks, cemeteries and allotment areas, show that rules-in-use, ecological knowledge and sense-of-place diverge considerably between managers of the different types of areas, with consequences for the generation of the three ecosystem services. The study highlights the significance of the different governance contexts within which they operate (*Paper II*).

The third section digs deeper into social features behind management practice in relation to ecosystem services in one of these land uses, namely allotment gardens. We explore the concept of social-ecological memory (SE-memory). SE-memory is defined as the means by which knowledge, experience and practice about how to manage a local ecosystem is retained and stored among a group of people, and modified and transmitted through time. SE memory of communities of practice like allotment gardens seems to be paramount for management of regulating and supporting ecosystem services underlying many prime resources (*Paper III*).

How such place specific qualities in management can be brought into adaptive governance structures for management of ecosystem services of the whole urban landscape is developed in the last study of this thesis. Tentative policy recommendations for how to strengthen the flow of urban ecosystem services in the urban landscape of Stockholm are provided (*Paper IV*) (se figure 1).



**Figure 1.** Scientific issues lead to papers, and paper results suggest new issues explored in subsequent papers.

## The approach of the thesis

The thesis is explorative in nature, and each paper has generated questions and hypotheses for the next (figure 1). We applied a diversity of methods to investigate social-ecological features and management practices of urban ecosystem services. Field studies were conducted in Stockholm, focusing on allotment areas, cemeteries, city parks, as well as on a park legally classified as being of national interest, called the National Urban Park (NUP).

Stockholm is situated at the boundary between the northern hemisphere boreal zone and the mid-European nemoral zone, and at the outlet of the freshwater lake Mälaren into the brackish Baltic Sea (59°20'N, 18°05'E). The physical landscape is shaped by the last glacial period 10.000 years ago and consists of fissured bedrock and clay covered valleys. The City was founded during the mid 1200s and the surrounding landscape has a long history of human-nature interactions. Stockholm city hosts a current population of 1.2 million people, which is growing with ca. 20.000 inhabitants per year, and the region holds 2500 inhabitants/km<sup>2</sup> (*Paper I*).

The first study is on the National Urban Park (*Paper I*). This park is located next to the inner city of Stockholm and covers 2,643 ha, of which 813 ha is open water. Few areas of equivalent size in Sweden show such a high biodiversity and the large populations of oak (*Quercus robur* and *Q. petraea*) in the park make it unique from an international perspective. We asked ourselves how such rich levels of biodiversity and the generation of relatively high abundance and quality of ecosystem services (see Table 2 of Paper I) was possible in a green area that is located close to the centre of a large capital.

In this park we conducted field observations, along with studies of historical and modern maps of the area as well as analyses of relevant written accords. In addition we did a telephone survey with stakeholders in the park, asking questions about their activities and where in the landscape they are active. Finally, three deep interviews were conducted with people that were central during the establishment of the park in 1995. This exploration generated a hypothesis for Paper II, which was whether some of the identified stakeholders or local stewards actually supported biodiversity and the ecosystem services that were generated.

In *Paper II* we test whether local management of urban areas actually supports ecosystem services. Here we focused on three types of land uses that can be found in the National Urban Park; allotment gardens, cemeteries and city parks and their management relations to pollination, seed dispersal and pest regulation. During field studies we combined ecological inventories of bumble bees and small birds in these three classes of land use, with interviews and questionnaires with the managers of these areas. The research led to another question; how are practices that generate and sustain ecosystem services stored and transmitted through time and between people? This became the overarching question for *Paper III* (see figure 1).

*Paper III* focuses solely on allotment gardens. Allotment areas are reserved for horticulture, containing tiny pieces of garden plots with individual or family management rights to land, which is usually owned by a local municipality. They are mostly located in urban or semi-urban areas, and appear as patches of intensively-managed flower rich areas, some considerably old, up to 100 years. Currently allotment gardens occupy 210 ha of land and involve about 24,000 people in the urban landscape of Stockholm.

Here we explore the concept of social-ecological memory for carrying ecologically benign management practices through time and between people. It builds on the data collected for Paper II and also employs deep interviews and questionnaires, in combination with literature studies on social memory (e.g. Halbwachs 1926 [1950]; Olick and Robbins 1998; Wenger 1998; McIntosh et al. 2000; Misztal 2003). Besides results and conclusions about social-ecological memory in relation to local management of ecosystem services, it also critically reflects on whether the concept is of value for governance of ecosystem services on larger spatial scales.

All three papers in combination lead to the fourth and last paper (*IV*) of this thesis, which again is explorative in nature. *Paper I* and *II* both recognizes gaps in the social network of governance for enabling ecosystem based management in Stockholm, and *Paper III* shows the importance of including local management for capturing processes of ecosystem service generation (see figure 1). *Paper IV* explores a multilevel and adaptive governance system with the capability of addressing three separated spatial scales of ecosystem processes, crucial for maintaining the flow of urban ecosystem services in Stockholm.

This last paper is a synthesis of seven case studies of ecosystem service management conducted in Stockholm and the frame of the synthesis is a combination of theory about ecosystem ecology and management (Holling 1978; Gundersson and Holling 2002; Bengtson et al. 2003) and structural network theory (Wasserman and Faust 1993; Burt 2002), which in combination are used to synthesize the findings of the case studies, and to suggest improvements.

The overall lens that is used for interpreting reality draws on *complex adaptive systems theory* (Byrne 1998; Levin 1998, 2003; Cilliers 1998; Crumley 2003; Lansing 2003; Norberg and Cumming 2008), and *resilience thinking* (Holling 1973, Walker and Salt 2006). The concept of resilience describes how a complex adaptive system can assimilate disturbance and continue to develop without crossing critical thresholds that would tip it into another domain of attraction, with different controls on structure and function (Carpenter et al. 2001; Folke 2006). Social-ecological systems (SES) (Berkes and Folke 1998) are prototypes of complex adaptive systems since ecosystem and societal processes are interlinked in evolving, non-linear relations (Gundersson and Holling 2002; Lansing 2003).

This lens of the thesis is used for applying an interdisciplinary approach, drawing on insights developed in *systems ecology and ecosystem management* (e.g. Holling 1978; Odum 1989a,b; Bengtsson et al. 2003; Folke et al. 2003), *anthropology* (Crumley 1994, 2000; McIntosh et al. 2000; Nazarea 2006) and other *social sciences* (e.g. Ostrom 1990; Hollis 1994; Hanna et al. 1996; Harvey 1996; Wenger 1998; Misztal 2003; North 2005).

### Management of urban ecosystem services

With the goal of illuminating how social-ecological features affect management of urban ecosystem services this section will discuss findings of the individual papers in relation to different theories. I will end by synthesizing the major findings generated in this thesis with the hope to contribute to increased understanding of how to incorporate the complexity of ecosystem service generation into governance of urban systems and their development.

### Scope of thesis for the on-going discussion

This thesis attempts to explore social-ecological features in relation to on the ground management of ecosystem services (MA 2005; Daily and Matson 2008). These include the role of actor and actor groups, with a focus on stewards of ecosystems services, their level of participation, collaboration and social networks, and how and where they generate, sustain and develop ecological knowledge and practice. The novel approach here is the combination of a long term perspective, interdisciplinary methods and the exploration of the role of social-ecological memory in relation to urban ecosystem services. Specific aims are 1) to analyze effects of past land use and of local current management practice on the generation of urban ecosystem services, 2) to explore how management practices, which are linked to ecosystem services, are retained and stored among a group people, and modified and transmitted through time, and 3) to suggest an organizational structure of governance that enables management of ecosystem services in the larger urban landscape.

The complex adaptive system and resilience perspectives emphasize that it is crucial to increase understanding of how to relate to ‘tipping points’ and multiple trajectories that may challenge or enhance essential ecosystem services (Folke et al. 2002; Folke, et al. 2004; Norberg and Cumming 2008). How can we design governance systems in relation to complex systems and tipping points? One strategy for dealing with complexity is to strike a balance between, on the one hand centralized power and responsibility, for effective collective action, and on the other, decentralized governance with diverse ways of monitoring and understanding the social-ecological system, with the potential to increase adaptive capacity for the whole (Duit and Galaz 2008; *Paper IV*).

Often lacking is the adaptive capacity of governance in relation to ecosystem services (Folke et al. 2003; Folke et al. 2005), which is one reason for putting forward decentralization of responsibility and power, and active involvement of stakeholders in adaptive co-management approaches (e.g. Gadgil et al. 1993; Christenssen et al.1996; Pomeroy and Berkes 1997; Dale et al. 2000; Gadgil et al. 2000; Dietz et al. 2003; Olsson et al. 2004; Selman 2004). Diverse and decentralized social networks of information and power (Crumley 1994, 2000, 2003), which are rich in ‘weak links’ (Granovetter 1973),

may be less effective at mobilizing collective action in times of rapid change, but seem to be good at capturing information and prepare prior the change. The reason is that decentralized social networks seem inherently equipped for monitoring and capturing of local change and for cross-scale sharing of information (Berkes et al. 2003; Folke et al. 2005). This is partly due to lower transaction costs, most notably costs incurred for describing and monitoring the ecosystem, designing regulations, coordinating users and enforcing regulations (McCay and Jentoft 1996; Johannes, 1998). Yet, the approach has encountered opposition in conceptualizing the complexity of current governance of social-ecological systems (Berkes 2004; Carlsson and Berkes 2005; Batterbury and Fernando 2006).

There are a number of challenges for humanity and society in relation to decentralization in co-management approaches, including ethical issues of fairness and distribution (Duffy 2006; Eakin and Luers 2006; Fennell et al. 2007; Ernstson 2008; McLaughlin and Dietz; *in press*; Cowling et al. 2008). Critique of research and implementation has been raised in relation to who is gaining or losing in such systems of governance (Batterbury and Fernando 2006; Blakie 2006; Lebel et al. 2006). In Stockholm, there are obvious trade-offs between ecosystem services generated from the National Urban Park, especially between recreational and supporting services, and contest for land is sometimes intense (***Paper I and III***). A co-management project here would need to fully take into account the contested nature of the past (Castro and Nielsen 2001; Misztal 2003).

One argument for decentralization of power and responsibility is that rules, discourses and meaning in relation to ecosystem service management, must be negotiated between local actors on the ground, since these will have to live and deal with local outcomes (Lyotard 1984; Cilliers 1998; Norton and Hannon 1996). From a holistic systems perspective (Hollis 1994), equally important is to take into account the tendency of powerful actors to superimpose top down practises on less powerful actors (Agrawal and Ostrom 2001; Ostrom et al. 2007). Decentralized governance increases the adaptive capacity for social networks when there is autonomy for actor groups and where localized dynamics are allowed to self organize and evolve (van der Leeuw 2000; Crumley 2003; Bodin et al. 2006), like in communities of practice (***Paper III***). However, as stressed in the adaptive and multilevel governance literature, such learning processes often need to be facilitated and supported by institutions at broader levels (e.g. Young et al. 2008), sometimes referred to as framed creativity (Folke et al. 2003).

History and contemporary examples show that if rare events and slowly changing ecosystem processes, underlying the resources, are ignored, unpleasant surprise may follow (McGovern 1994; van der Leeuw 2000; Huitric 2005; Steneck et al. 2008). Consequently, it is not enough to assume that 'good governance', will automatically result in sustainable use of resources, while simultaneously ignoring the ecology of SES (Pretty 1995; Acheson et al. 2000; Brown 2003; Pound et al 2003). This thesis takes on the challenge of exploring social features that captures, retains and develops social-ecological processes, underlying desired ecosystem services.

The landscape of the National Urban Park in Stockholm (*Paper I*) owes its current flow of ecosystem services to co-evolutionary processes of people and nature, ignited several thousand years ago as land for people was first provided by the land-uplift. When enough fine sediment soil was exposed, people used them for agriculture and continuously transformed the landscape according to secure their needs. Since then major transformations of the relationship between the inhabitants and the environment have occurred driven by rapid social changes. Physical structures in the landscape, such as giant oaks, meadows, and urban gardens can be considered as legacies of these transformations (Foster et al. 2003) representing habitats from where desired ecosystem services flow today.

In an historical account of land uses of the National Urban Park it became clear that the resilience of this landscape to produce ecosystem services is linked to surrounding ecosystems as well as to historical property and management rights, and the involvement of a diverse set of stewardship groups that take active part in practical management of the park. The high species diversity currently found there relates to past activities in land use, and thus, relies on continued management. Hypothetically, sustaining the flow of ecosystem services there will depend on governance that is sensitive of slowly changing variables of land use, of social diversity of actor groups involved in management and of management rights. Hence, sustaining ecosystem services in urban areas is not about conservation without people, but shaped by and dependent on management practice by people.

*Paper II* shows that the analyzed social features of management; rules-in-use, ecological knowledge and sense-of-place, differ significantly, and that this affects practices, linked to the three functional groups of ecosystem service providers. The results show the ecological affects of these social differences, primarily in terms of higher abundance of pollinators in the informally managed allotment gardens (see figure 2 of paper II), and as differences in the composition of seed dispersers and insectivores. Thus, voluntary management motivated by sense of place, which is normally undervalued by planning authorities, is important for the generation of ecosystem services in the urban landscape. Furthermore, this paper suggests that management has an important secondary function: it may be crucial during periods of instability and change by promoting risk reducing practices that address ecological processes that are important for responding to disturbances, such as enhancing habits for ecosystem service providers of pest regulators. The research generated questions whether, participation of citizens in management of green areas which now are managed solely by employed personnel, such as city parks, could result in similar positive results as allotment gardens, and if practices that supports ecosystem services can be retained and stored among such self organized management groups, and transmitted through time?

*Paper III* builds on findings of paper II and explores *social-ecological memory* in relation to management practice that sustains ecosystem services, and investigates where and how social practice of local social-ecological systems is retained and transmitted.

Social practice (Bourdieu 1978; Ortner 1984), implies an actor centered perspective as an important complement to a holistic systems perspective (Giddens 1979), and ultimately it is about how we experience the world and our engagement in it as meaningful (Wenger 1998). We found that the allotment gardens function as communities-of-practice (ibid.), where participation and reification interact and social-ecological memory is an emergent structure that persists by being both perturbable and resilient. Community of practice is here used as informal groups of people characterized by dense relations and mutual engagement, as well as shared stories, jargon and ways of doing things together.

Social-ecological memory in the urban gardening is retained and transmitted through participation in mimicking practices, learning processes, oral communication and collective gatherings. It also resides in structures of chalets and garden plots and other physical forms and artifacts as well as a number of rules-in-use (institutions) of allotment gardening. Finally, a wider social context provides an external support structure, through various forms of media, social networks, collaborative organizations, and legal structures. We conclude that social-ecological memory holds a role in sustaining ecosystem services in times of crisis and change and that it enables resource users and managers to address slow underlying, and therefore often 'hidden' ecosystem processes of many resources and ecosystem services, and that it determines success or failure of navigating away from complex tipping points of undesirable trajectories.

Although physical sites that allows for stewards on the ground to engage in local management are important for the reasons above, it is equally important to engage in management of the whole landscape for the production of ecosystem services since its spatial configuration is critical to the supply of many services (Goldman et al. 2007). The final paper of this thesis (*Paper IV*) attempts to up-scale the findings of the previous papers for addressing how qualities of local management can be brought into governance, and how to design a social network structure of governance in order to overcome spatial scale-mismatches. This paper is visionary as it gives policy directions of governance that allows for ecosystem based management of the whole urban landscape with the aim of sustaining the flow of ecosystem services, and as such, it is recognizing imagined futures as objectives of human actions. This implies dealing with settings of actors that differ quite substantially in terms of preferences, social, economical and political resources and social practices (Wenger 1998; Galaz 2005). High heterogeneity of actors in management of ecosystem services often increases potentials for distrust and conflict (Castro and Nielsen 2001; Walters 1997). Institutional entrepreneurship like brokering between actors is suggested to serve as a bridge over such troubled waters (Westley and Vredenburg 1991; Granovetter 1973; Burt 1992; Hahn et al. 2006).

Brokering according to a structural network perspective, is about structural position in social networks, or more precisely about actors occupying positions that enable them to create relationships between disconnected clusters of actors. However, brokerage is not just about structural position; it is also about social practice (Wenger 1998; Westley 2002; Hahn et al. 2006). It requires enough legitimacy to influence the evolution of practice of different actors, to address conflicting interests and to build trust (Wenger 1998; Olsson et al. 2004; Hahn et al. 2006).



In *Paper IV* we use structural network theory (Granovetter 1973, Wasserman and Faust 1994, Burt 2002) and ecological scales for a discussion of how the practice of scale crossing brokers can increase the flexibility of an spatially explicit adaptive governance, required for overcoming misfits and for an ecosystem based management in this urban landscape (*Paper IV*). It provides tentative policy directions including facilitating for the emergence of actors that engage in sale crossing brokering, as well as for appointing actor groups that focus on ecosystem management of the spatial mid-scale. (*Paper IV*).

### Large scale processes affecting urban ecosystem services

Why is management of ecosystem services, in urban landscapes, a complex issue? Cities are both endpoints of human domestication of landscapes (Karieva et al. 2007) and simultaneously complex adaptive systems (Byrne 1998). A general difference in the relations between society and ecosystems in rural vs. urban landscapes is that in urban landscapes the faster social dynamics increasingly sets the pace for and dominates ecosystem dynamics (van der Leuw 2000). This restlessness is partly due to flows enabled by the positions urban landscapes hold in a global network of cities (Castells 1996; Fyfe and Kenny 2005). Urban landscapes are experiencing rapid and continued transformations (*Paper I*; Cox 2005), putting pressure on remaining urban ecosystems (Collins et al. 2000. Grimm et al. 2000; Kinzig and Grove 2001; Alberti et al. 2003; May 2004, Pickett et al. 2008; Wallace and Wallace 2008) and on physical sites that allow for participation in the actual management of ecosystem services (Colding 2009).

Such continued changes may weaken and erode ideas and values about peoples' dependence on ecosystems also outside cities. This is alarming since it may challenge broad-based public support for combating the decline of ecosystem services (MA 2005) both inside and outside urban landscapes. The estimated reason for this erosion is the decreasing possibilities for city-people of personally engaging with ecosystems (Pyle 1978; 1993; Theodori et al. 1998, McDaniel and Alley 2005). Without first hand personal interaction the motives of learning and care seem to dissolve and ultimately disappear (*Paper II*).

Viewed in this context, this thesis argues that urban governance for management of ecosystem services holds pedagogic responsibility for creating opportunities for citizens to actively engage with ecosystems. This is important not only for building broad based support for stewardship and sustainability, but also for developing important local social-ecological processes of management of ecosystem services on the ground (*Paper III*).

### Consequences and responses in Stockholm

The ecological consequence in Stockholm is a gradual loss of ecosystems for constructions and development that tends to lead to isolated and small-sized green areas. This means that habitat suitability of a patch, for ecosystem service providers such as bees and small birds, is to a large extent dependent on its surroundings (*Paper IV*). Some species become dependent on small scale networks of one type of green areas while others need access to several different types (Colding 2007; Lundberg et al. 2008).

The small sizes of ecosystems also increase the probability that many organisms will exhibit meta-population dynamics with local extinction and re-colonization as shown by other studies in Stockholm (Mörtberg 2001) and elsewhere (Reale and Blair 2005). Hence, managing local ecosystems in isolation will fail (*Paper I*) the surrounding city-green-network has got to be taken into account as well (*Paper IV*). At the regional scale a system of larger green areas, or “green wedges”, as well as areas of national interest are recognized by authorities as providing landscape connectivity thus potentially replenishing sink populations of local green areas (cf. Sandström et al. 2006; cf. Crooks et al. 2004).

Such fragmentation is common in urban landscapes and has been argued to produce a higher tendency of scale mismatch, i.e. when there is a temporal or spatial mismatch between the scales of ecological processes and the processes of governance that frames ecosystem management (Folke et al. 1998; Cumming et al. 2006). Green governance of Stockholm includes land use planning, policy development and practical management on the ground. Despite good intentions there are scale mis-matches, partly because no actor group is purposely addressing the spatial scale between local ecosystems or habitats and regional green wedges, known as the mid-scale, of the urban landscape, which have been stressed as important in urban landscapes (cf. Byrne 1998; Borgström et al. 2006; Cumming et al. 2006). *Paper IV*, calls this scale the city-green-network.

At local levels a considerable amount of small ecosystems and their stewards, such as allotment gardens and cemeteries, are classified as “developed land” and not recognized for their ecological roles (Colding et al. 2006). The fair amount of informal and motivated stewardship groups that take direct part in habitat management and conservation, tend therefore to be undervalued by planning and management authorities. However, there is limited knowledge within each local actor group of spatial scales larger than the area that they manage (*Paper II*). Management authorities in Stockholm have a landscape perspective, but there is lack of ecological knowledge integration between the landscape managers and the local stewards, which re-produce the tendency of scale mismatch (*Paper IV*).

#### The role of social-ecological memory in communities of practice on the ground

The results of the first three papers show that some local groups that take part in active management on the ground, such as nature enthusiasts, allotment gardeners and cemetery managers, plays a role in the production of urban ecosystem services. Firstly, it shows that their different management practices generate different habitats and biotopes. Secondly, it also shows that some local groups support the generation of ecosystem services by enhancing in situ habitat quality for some ecosystem service providers. For instance, management practices in allotment areas positively affect the diversity and abundance of wild bees, which spills over into the urban landscape, and the increased heterogeneity that the gardens have on the urban landscape, also increases the overall diversity of insectivores birds (*Paper I, II and III*). Consequently, local informal management plays an important role in management of ecosystem services, but what is it really that motivates informal and often voluntary managers in urban landscapes?

One important factor is the temporal length of engagement. It is the long-term engagements in physical sites that allow for participation of citizens in the actual management of ecosystem services that create motives for voluntary management (*Paper III*). Rights to engage in the long term are incentives for managers to invest in rules-in-use, as well as in physical objects. Such ‘objects’ tend to outlive the repertoire of practices that first created them and they load the place with shared histories of ongoing processes of learning and negotiation about meaning. This results with time in an emotional attraction, referred to here as sense of place. Continued labor and participation deepens the sense of place further (Norton and Hannon 1996).

Sense of place is estimated as crucial for keeping urban actors in civil society motivated to engage in practical management of urban ecosystem services, as people are not economically reliant on them (*Paper II*). The feedbacks between an urban ecosystem and its stewards are indirect or weaker than in most rural SES. Usually, it is not feedbacks related to livelihood, such as food, fiber and material products (Berkes et al. 2003) that motivate urban local stewards of ecosystems, but it is rather social features, such as the recreation, sense of place or employment, as for park- and cemetery managers.

Long term engagement in urban landscapes requires enabling legislation (Olsson et al. 2004), more precisely robust property rights (Ostrom 1990), since contest for land is intense here (*Paper I and III*). Allotment areas in Stockholm, for example, hold leaseholds on long-term basis. Renewable leaseholds up to 25 years between a local allotment association and the local municipality are common. Not surprising then is that these associations contain well managed cottages, gardens and long lived organisms, such as fruit trees, as well as they hold most of the characteristics described for communities of practice, including a high degree of freedom in decision making (*Paper III*).

Long term engagement is important not only for motivating local managers to continue their management, but also for developing place specific SE-memory (*Paper III*; Gunn 1994; cf. Wenger 1998; Muchagata and Brown 2000; Ballard and Huntsinger 2006). Social-ecological systems not only evolve through time, but their past is often reflected in their present functions (cf. Levin 1998, 2003; cf. Foster et al. 2003). Hence, in order to respond successfully to changes, any ecosystem manager must be able to capture information and experiences and continuously learn about the social-ecological system, and store it for future use (Gunn 1994; Cilliers 1998; Folke et al. 2003).

SE-memory related to allotment gardening is an emergent structure of their community of practice (*Paper III*). This emergent structure is created in a dual process of participation and reification. Participation is a source of social-ecological remembering and also of building identities and thus deals with our need to recognize ourselves in our past. Participation ignite reification processes that generate ‘things’ that functions as shortcuts to communication, and which tend to persist, such as metaphors, artifacts and physical objects, and also of which some will change according to their own laws, such as shared jargon. The ‘things’ that are generated in reification processes are linked to ecological dynamics which they tend to reflect.

However, SE-memory is constantly modified not only because we forget and remember partially, but also because the world is in constant motion and since our forms of participation change. The consequence is that any practice must constantly be reinvented even though it remains ‘the same practice’ (*Paper III*).

The emergent structure of SE-memory enables resource users and managers to be exposed to slow changing processes and rare events, such as changes in pollination capacity and pest out-breaks, via positive feedback cycles of practice and monitoring, where monitoring is facilitated by SE-memory (*Paper III*). It has been suggested that slow variables are defining the underlying structure of social-ecological systems, whereas fast variables reveal the dynamics of this underlying structure (Carpenter et al. 2001; Carpenter and Turner 2001). A narrow focus on faster dynamics only, will always undermine a system, since ignorance of slow variables that play out on the longer-term automatically leads to accumulation of potential risks (Holling and Meffe 1996; van der Leeuw 2000). This is a reason why captured and stored information of slowly changing processes is of importance for ecosystem management.

Drawing on the notion that acquisition of novel practice typically follows resource crises (Folke et al. 2003; Berkes and Turner 2006) and in combination with the theory of SE-memory developed in this thesis, it is reasonable to think that information about environmental events is retained in reification processes. In allotment gardens, such information is reflected in risk reducing practices, for instance by habitat improvement for service providers (*Paper II*), which subconsciously prepares gardeners for up-coming disturbances (*Paper III*). Such features of SE-memory often lies beyond the cognitive and rational, as it is carried in habits (Misztal 2003), and it functions as mental maps for decision making in a complex world, and can be reflected in practices that build local social-ecological resilience (*Paper III*).

### Concluding remarks

The Millennium Ecosystem assessment concluded that the capacity of ecosystems to generate important services has deteriorated as a consequence of human action. But that humanity, through improved governance systems, has the potential to advance our management of ecosystems and secure their resilience for the future (MA 2005).

In democratic societies improved governance for management of ecosystem services requires motivated citizens, of which over 50% now live in urban landscapes. The thesis exemplifies that personal experiences with green area management in urban landscapes facilitate citizens to develop meaningful and emotional motivation for engaging in ecosystem management (*Paper II*). It also highlights that there are actors and actor groups that already function as local stewards of urban ecosystem services, a role seldom recognized in urban planning or governance (*Paper I*). The thesis makes the point that urban ecosystem services are a product of co-evolution of people and nature, and analyzes the role of local stewards and communities of practice in management of ecosystem services. Results illuminate how urban ecosystem services are generated in complex and actor driven social-ecological processes.

It does so by applying a long term perspective of such processes, starting by a historical description of interdependent social-ecological processes and by exploring how current actor groups are linked to the generation of ecosystem services (*Paper I*). It continues through interdisciplinary analyzes of contemporary land uses in cemeteries, allotment gardens, and city parks and their local management and governance (*Paper II*), and stretches into the human sphere, by illuminating how social-ecological memory enables practices of local management that links to ecosystem services, such as pollination, seed dispersal and pest regulation, and that such practices simultaneously create experiences of meaning (*Paper III*).

The thesis illustrates the benefits of creating incentives for ecologically engaged people that are aware of the significance of ecosystem services for societal development to participate in their management. This calls for governance to appreciate and actively include citizens in on the ground management of urban ecosystem services, whether it is about sustaining urban green areas or developing new ones. Creating opportunities for urban people to actively engage with ecosystems should be prioritized in urban governance, for example through creating platforms or arenas of collaboration, such as co-management arrangements and connecting uncoordinated actor groups and social networks. Decentralization for self organization seems to build diversity and resilience for responding to change. Adaptive governance schemes that support such processes in multilevel governance systems could be developed and implemented for urban ecosystem management (*Paper IV*). It would provide opportunity for centralized cross-level coordination and collaboration, of particular significance when periods of major crises or challenges arise (e.g. Olsson et al. 2008). This thesis also illustrates that robust long term property and management rights are crucial in this respect (*Paper I and III*).

Consequently, local communities of ecosystem practice in civil society, which contribute to the production of ecosystem services, should explicitly be taken into account in urban green governance of the urban landscape of Stockholm. Their participation could be realized by training and appointing scale crossing brokers that enable information flows between management on the ground and state agencies, without superimposing top-down practices by suggesting 'blueprint' management and planning (Holling and Meffe 1996; Ostrom et al. 2007). This is one possible way to overcome present scale-mismatches, and a possibly intelligent network structure of urban green governance (*Paper IV*).

Identity, sense of place and social-ecological memory motivate local communities of practice, and link their practices to place specific processes. Such kind of qualities of local communities of practice complement the general ecological knowledge held by scientists and management authorities, and need to be considered when negotiating governance of ecosystems of the world for securing its benefits for the generations of people that will follow us (Gunderson et al. 1995; Becker and Ghirnire 2003; Chalmers and Fabricius 2007).

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Research, part of a Special Feature on [Strengthening adaptive capacity](#)  
**History and Local Management of a Biodiversity-rich, Urban, Cultural Landscape**

*Stephan Barthel*<sup>1</sup>, *Johan Colding*<sup>2</sup>, *Thomas Elmqvist*<sup>1</sup>, and *Carl Folke*<sup>1</sup>

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**ABSTRACT.** Urban green spaces provide socially valuable ecosystem services. Through an historical analysis of the development of the National Urban Park (NUP) of Stockholm, we illustrate how the co-evolutionary process of humans and nature has resulted in the high level of biological diversity and associated recreational services found in the park. The ecological values of the area are generated in the cultural landscape. External pressures resulting in urban sprawl in the Stockholm metropolitan region increasingly challenge the capacity of the NUP to continue to generate valuable ecosystem services. Setting aside protected areas, without accounting for the role of human stewardship of the cultural landscape, will most likely fail. In a social inventory of the area, we identify 69 local user and interest groups currently involved in the NUP area. Of these, 25 are local stewardship associations that have a direct role in managing habitats within the park that sustain such services as recreational landscapes, seed dispersal, and pollination. We propose that incentives should be created to widen the current biodiversity management paradigm, and actively engage local stewardship associations in adaptive co-management processes of the park and surrounding green spaces.

**Key Words:** *ecosystem services; local management; Nationalstadsparken; resilience; social-ecological system; Stockholm Urban Park; urban ecology*

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## INTRODUCTION

Urban ecological systems have been described as profoundly different from non-urban systems, with some of the most diverse ecological conditions on the planet (Collins et al. 2000, Grimm et al. 2000). Urban green spaces are highly patchy and dynamic, formed by biophysical and ecological drivers on the one hand, and social and economic drivers on the other (Pickett et al. 2001). Given the accelerating rate of urbanization worldwide, urban green spaces are becoming increasingly important to society as nodes of interactions between humans and nature. Urban green spaces generate a diverse set of ecosystem services of substantial significance for human well-being (Bolund and Hunhammar 1999). Their dynamics are shaped by human activities in what we refer to as a coupled social–ecological system (Berkes and Folke 1998).

Many green spaces in cities that have become disconnected from the wider environment tend to lose biodiversity and erode (Recher and Serventy 1991, Drayton and Primack 1996). Hence, protecting green spaces in isolation will often fail to sustain the capacity of urban ecosystems to generate services. Revitalization and broadening of the current management system from conservation in legally protected areas to stewardship of the urban landscape is a direction put forward in Swedish policy (Swedish Government 2002). It involves bringing nature management closer to the citizenry and acknowledging the diversity of user and interest groups that have a stake in management.

In this paper, we analyze the emergence of a larger urban green space, a cultural landscape currently known as the National Urban Park (NUP) of Stockholm (Elmqvist et al. 2004) (Figs. 1 and 2). In an historical account, we describe how the area has been transformed and governed by human actions

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and cultural influences, beginning with a low human-impact period, and currently facing a period of high urbanization pressure that, in 1995, resulted in legislative protection for the park. Most likely, an integrated management approach that incorporates surrounding land uses and green wedges will be required for the NUP (Colding et al., in preparation) (Fig. 1).

We also identify, by means of a social inventory, the main groups of actors in the NUP (Schultz et al. 2004). When conducting ecological research in urban areas, a social inventory is crucial because it provides clues on how to design and stimulate the development of more effective biodiversity management systems. In this context, we emphasize the existence of numerous local stewards and local stewardship associations involved in the management of the NUP. Such stewards include individuals and groups of people involved in the management of natural resources, habitat, and ecosystems. They tend to operate at a local scale, often below the municipality level, and their engagement may be voluntary, with an interest in stewardship. They are often socially connected in networks across vertical and horizontal levels (Olsson et al. 2004). In our view, such local groups represent an undervalued, sometimes not even recognized, source of experience in ecosystem management and governance. Finally, we discuss how their integration in adaptive co-management systems may provide more efficient management of biodiversity and ecosystem services in the NUP.

This paper is part of the Swedish contribution to the Millennium Ecosystem Assessment (MA) ([www.millenniumassessment.org/](http://www.millenniumassessment.org/)), and part of the research of the Stockholm Urban Assessment (SUA-Sweden) ([www.ctm.su.se/SummaryofStockholmUr/](http://www.ctm.su.se/SummaryofStockholmUr/)). The objectives of SUA-Sweden are to investigate how adaptive capacity can be built to better respond to social-ecological change, and more specifically, to find effective ways to manage urban ecosystem services. The aim is to provide knowledge for designing governance systems that better take into account social and ecological dynamics and critical scales in biodiversity management for the well-being of the urban population of Stockholm (Colding et al. 2003, Elmqvist et al. 2004).

The paper begins with a description of the study area (Fig. 2), followed by information on the methods used for the historical account and the social

inventory. We then describe the historical development of the NUP, showing how influential drivers, such as property rights, changes in human perceptions of nature, the industrial revolution, and urban population growth, have contributed to the formation of its various ecosystems and its current rich biodiversity. In the next section, we present an inventory of key local stewards and associations that operate the various sites (biotopes/habitats) in the park, and analyze their bundles of rights to resources in relation to the ecosystem services of the area. Based on this information, we discuss management implications for co-evolved, social-ecological systems in an urban context.

## STUDY AREA

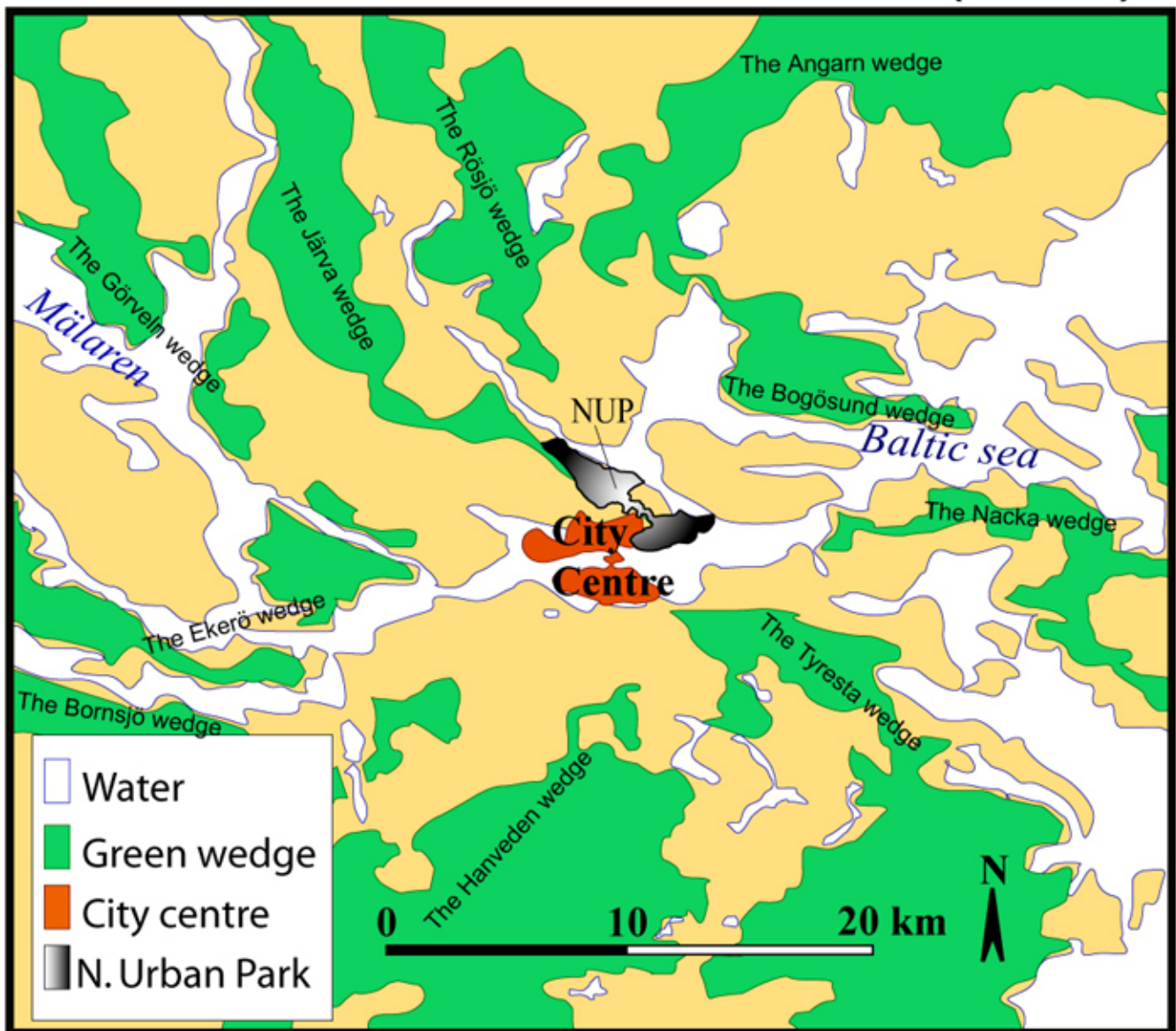
Stockholm County has one of the largest population concentrations in Scandinavia, with about 1.8 million people. The city of Stockholm, the capital of Sweden, has 750 000 residents ([www.ab.lst.se](http://www.ab.lst.se), see Elmqvist et al. 2004). The case studies of SUA-Sweden focus on the greater metropolitan area of Stockholm County, with special attention given to the NUP and its surrounding green space. This green space is connected to the larger green structure by one of ten green wedges that extend from the rural parts of the County toward the center of Stockholm (see Fig. 1).

Figure 1 shows the location of the NUP, the focal point of this paper. The NUP is located next to the inner city of Stockholm, situated between Lake Mälaren and the Baltic Sea. The park covers 2643 ha, of which 813 ha is open water, and forms the largest green space structure in the northern and eastern parts of Stockholm (Löfvenhaft 2002b). Three municipalities share the land, and the park borders four other municipalities. The park extends from the landward end of the Stockholm archipelago, via Djurgården and Haga-Brunnsviken, to the grounds of Ulriksdal Palace to the northwest (see Fig. 2). The large populations of oak (*Quercus robur* and *Q. petraea*) make the park unique from an international perspective. Also, few areas of equivalent size in Sweden show such a high biodiversity as the NUP (Löfvenhaft 2002b, Bråvander and Jakobsson 2003).

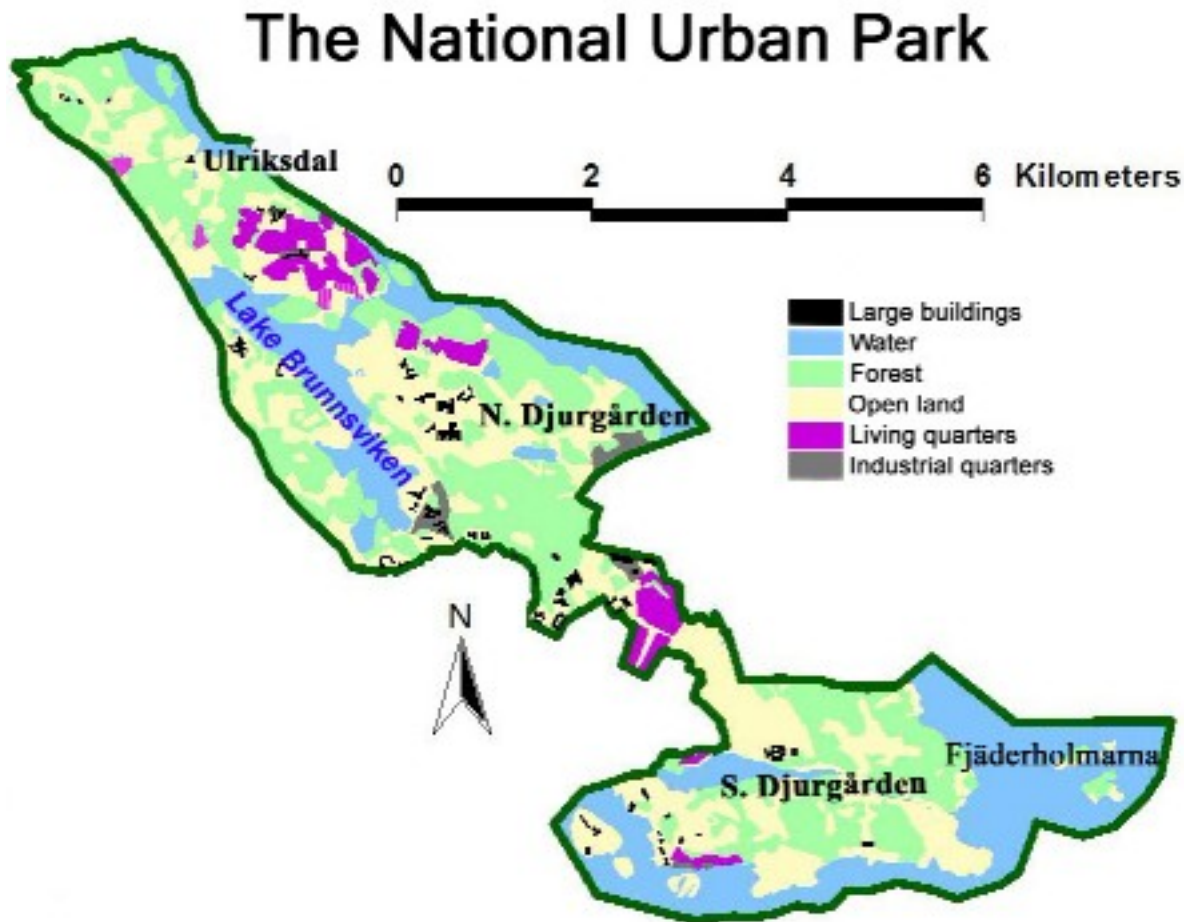
Since 1995, the park has been governed by a specific law under the Swedish Environmental Code as an area of national interest. The area is the first National Urban Park in the world. It owes its legal protection

**Fig. 1.** Overview of the green space structure in Stockholm and the location of the National Urban Park

# Stockholm overview, green wedges and the National Urban Park (NUP)



**Fig. 2.** The National Urban Park



to various pressure groups, and can be viewed as a response to local concerns about loss of green space. The law stipulates that new buildings and new facilities within the area may be developed and other measures taken only if they can be done without intruding on the park's landscape or natural environment, and without causing harm to the landscape's natural and cultural values (Rubenson 2000). However, despite legal protection, urban sprawl has not been halted on the park's fringe areas. Aside from its biological value, the park has unique historical and cultural values. It is estimated that the NUP attracts 15 million visitors each year, many of whom visit the park for recreational purposes (Stockholm Planning Administration 1997).

Water characterizes much of the rift valley landscape of the NUP. A number of islets, especially *Fjäderholmarna*, have a rich flora and bird life typical of the archipelago. *Djurgården*, on the shoreline of the Baltic Sea, has lush vegetation and landscape characteristics typical of the Stockholm archipelago: low-elevation, pastoral meadows and bedrock populated with scattered Scots pine (*Pinus sylvestris*). There are also a number of wetlands and small water bodies. The royal heritage of the NUP can be seen in the vast lawns, scattered broadleaf trees, alleys, forested hills, and dense forests. In addition, there are culturally shaped pastures with rich ground flora, and bedrock outcrops with dry land flora (Stockholm County Administration Board 1999). There are three royal castles in the

park: Rosendal, Haga, and Ulriksdal. English-style landscape parks characterize the landscape around Lake Brunnsviken, with lookouts over the lake and 15<sup>th</sup> century buildings with large lawns. The renaissance-style park typifies the locale around Ulriksdal, located on the coast (see Fig. 2).

Urban gardens are another element that characterizes the park. A botanical garden, Bergianska, is situated along the shoreline of Lake Brunnsviken. It contains 32 ha of gardens and different forest biotopes, including about 9000 species of plants (Edlund 1991, Lundevall 1997). Another popular example is the garden at Rosendal, which focuses on organic horticulture (<http://www.rosendalstradgard.com/>).

In addition, there are six allotment gardens in the park, a number of recreational establishments (such as an amusement park and a theatre), several museums, and several scientific and educational establishments, as well as permanent residential houses, and even whole city quarters with large apartment buildings. Löfvenhaft and Lannek (2002) have classified up to 24 different biotopes within the NUP (see Table 1). For a complete description of urban green spaces in the Stockholm metropolitan area, see Colding et al. (in preparation).

## METHODS

The study of human influences on urban ecosystems stresses the importance of analyzing interacting social dynamics as well (Kinzig 2001, Berkes et al. 2003, Olsson et al. 2004). In this paper, analyses of social dynamics that affect contemporary ecosystem dynamics in the park include 1) an historical survey of past land uses and management of the park, 2) a social inventory (Schultz et al. 2004) of stewardship groups that are currently active in the park, and 3) a qualitative assessment of ecosystem services linked to these stewardship groups.

The methods employed for describing the historical development of the park include a study of the literature and of relevant maps, and information derived from the Internet. The NUP of Stockholm is a rather well-documented area (e.g., Edlund 1991, Brusewitz and Ekman 1995, Fogelfors and Hansson 1997, Lundevall 1997, Stockholm Planning Administration 1997, Stockholm County Administration

**Table 1.** Number of different types of biotopes found within the National Urban Park

<b>Biotopes in the National Urban Park</b>	
1	Developed land with sparse vegetation cover (0–30%)
2	Developed land with dense vegetation cover (30–50%)
3	Dense broadleaved deciduous forest
4	Sparse broadleaved deciduous forest
5	Deciduous forest
6	Mixed forest
7	Coniferous forest
8	Bedrock with scattered Scots pine
9	Moist grassland with trees and shrubs
10	Mesic grassland with broadleaved deciduous trees or other vegetation
11	Dry grassland with broadleaved deciduous trees or other vegetation
12	Bedrock with broadleaved deciduous trees or other vegetation
13	Moist grassland
14	Mesic grassland
15	Dry grassland
16	Arable field or allotment
17	Bedrock outcrops
18	Remaining bare ground
19	Wetland with sparse vegetation
20	Wetland with dense vegetation
21	Wet deciduous forest
22	Open water with floating vegetation
23	Floating water vegetation
24	Grassy shallow water

Source: Löfvenhaft and Lannek 2002

Board 1999, Lange 2000, Herdin 2002, Norrby 2002, Holm and Schantz 2002, Wirén 2002, Löfvenhaft 2002b, Andersson 2003, Borgström 2003). A number of maps of the area have been analyzed. Although some of these maps are over 300 years old (<http://www.djurgardskartor.lantmateriet.se/>), we have mainly used recently produced biotope maps, such as the work by the Stockholm Planning Administration (1998), and Löfvenhaft and Lannek (2002).

The social inventory of the NUP was carried out in 2003. The results from the social inventory described in this paper focus on stewards dealing with green space management and user groups in the NUP, as well as the various user and property rights held by them. Thus, the paper presents information on social factors that influence the management dynamics of the NUP. Multiple forms of qualitative data (Patton 1980, Fowler 1993, Bernard 1994, Kvale 1996) were used to identify the park's user groups and stewardship groups, including internet searches, telephone surveys, field and participatory observations, map analyses, and a literature review (Appendix 1 provides details on the websites and maps consulted during this research, and on the interviews conducted with stakeholders). Semi-structured interviews were carried out between March and May 2003, and the interviews each lasted for about 1 hour. The interviewees were active when the park received its legal protection and have inside knowledge of locally evolved interest organizations in the park. They are also active in the network organization *Alliance of the Ecopark* (<http://www.ekoparken.org/>). A telephone survey was conducted in 2003, with 69 identified organizations in order to obtain further information on whether they were active in management or not, where in the landscape they were active, and what kind of property rights they held (see Appendix 2, Table 2). All 69 organizations responded.

Following this, a qualitative attempt was made to assess ecosystem services provided by sites, as managed by stewardship groups. We estimated that these managed sites hold specific ecological processes and habitats for various compositions of species. We focused on the landscape scale in this inventory, and more specifically, on the heterogeneity of the landscape and ecosystem services provided by biotopes on a landscape level. Criteria were synthesized from the literature for

connecting various types of urban green space or biotopes with characteristic ecosystem services (Folke et al. 1996, Baskin 1997, Costanza et al. 1997, Daily 1997, Daily et al. 1997, Nabhan and Buchmann 1997, Naylor and Ehrlich 1997, Niemi et al. 1998, Bolund and Hunhammar 1999, and Löfvenhaft 2002a). The link between ecosystem services and actor groups was made using these criteria (see Table 3) when analyzing various types of sites, as managed by the stewardship groups. Four characteristic ecosystem services per site were chosen, in order to highlight that the various sites differ in the services they offer to the urban landscape, and some sites may, to varying degrees, support other ecosystem services as well.

## **THE SOCIAL–ECOLOGICAL HISTORY OF THE NATIONAL URBAN PARK**

In this section, we analyze the social–ecological co-evolution of the biodiversity-rich landscape of the NUP of Stockholm. To best present the history of this development, we have divided it into five periods, representing what we find to be major transformations in the relationship between the inhabitants and the environment: the agricultural period; the royal hunting period; the forestry and recreational period; the industrial period; and the urban sprawl period (see Fig. 3).

### **The Agricultural Period**

The NUP is located in an area of Sweden where the landmass has risen above sea level by about 5 mm a year since the latest ice age (Loberg 1993). During the Bronze Age, the shoreline was about 14–20 m above the present-day shoreline. As soon as the first islands rose above sea level, they attracted hunter and gatherer societies, as is revealed by artifacts found in Bronze Age graves. Later, during the early Viking era, enough fine sedimentary soil was exposed to permit people to settle in villages and create an agricultural landscape (Lundevall 1997, cf. Bratt and Stockholms Läns Museum 1998). At that time, the shoreline was about 5 m higher than presently. Thus, there has never been a pre-human period in the current NUP area. The landscape was shaped by human action ever since land uplift processes provided suitable habitat for settlers (Gustavsson 1998).

**Table 2.** Potential ecosystem services generated by urban green space of the NUP, and the number of local stewardship associations involved in managing and sustaining them

Potential urban ecosystem services	Criteria for green space and biotopes, delivering each ecosystem service	Number of stewards with different property rights that affect each ecosystem service		
		Owners	Proprietors	Claimants
<b>Experiential services</b>				
Recreation/cultural values	Green space in NUP open to and enjoyed by the public	4	7	5
<b>Regulating services</b>				
Noise reduction	Street trees, lawns or urban forests close to noisy areas	5	6	0
Insect pest regulation	Habitat for predators of pests	1	8	1
Surface water drainage	Permeable surfaces like lawns, etc.	3	2	0
Regulation of microclimate	In city vegetation/street trees, vegetation close to buildings, and water bodies	3	2	0
Air filtration	Street trees, lawns or urban forests close to sources of pollution	5	0	0
Nutrient retention	Wetlands	0	2	2
<b>Supporting services</b>				
Seed dispersal	Important feeding areas and habitats for mobile links	1	10	4
Pollination	Important feeding areas for pollinators	0	11	2
Gene conservation	Areas in NUP described as important habitats for red-listed species	2	4	5

Since the Viking era, there have been numerous shifts in land use in the area that constitutes the contemporary NUP. The dominant land use during the first half of the second millennium was agriculture. The present-day land mosaic in the NUP consisting of open land areas and forests was established during the agricultural land-use era (see Fig. 4). Broadleaf stands, especially oak (*Q. robur*) trees, were favored (Stockholm County Administration Board 1999). In the Middle Ages, the primary landowners were monasteries and the church. The first regulations concerning oak as a natural resource were written during this period, in 1347, oak being valued then for its hardwood and its acorns (Herdin 2002). Between the 13<sup>th</sup> and 15<sup>th</sup> centuries, the monasteries increased their

landholdings, but over time, members of the royalty became attracted to the area and slowly changed the land use. In 1452, the southern sector of an area called “Djurgården” (see Fig. 2) became royal property, and a century later the entire locale was at the disposal of the Swedish King Gustav Vasa (Stockholm Planning Administration 1997). This marked the beginning of a royal management tradition that, to some extent, continues today. Grazing was intensified after the royal takeover, affecting natural regeneration of broadleaved trees. The park’s forests were estimated to be in poor condition by the end of the agricultural period (Herdin 2002).



**Table 3.** Local stewardship associations involved in the management of the National Urban Park

Stewards: Organizations and associations	Number	Property Right	Level of governance			
			Global	National	Regional	Local
World Wildlife Foundation (WWF); the Swedish Society for Nature Conservation; Patrullen Utter; Bergshamra för alla; Stockholms Ornitologiska förening	5	Claimants	1		1	3
Stockholm Water Inc.; Royal Djurgården Admin.; Botanic Garden of Bergius; Garden of Rosendal; the 4H Farm of Stora skuggan; Allotment areas of Söderbrunn, Kvarnvreten, Ulriksdal, Frescati, Bergshamra, and Stora skuggan; Outdoor Museum of Skansen; Cemetery of Ulriksdal	13	Proprietors			1	12
National Property Board; Swedish National Road Administration; Vasakronan; Akademiska hus; Municipalities of Stockholm, Solna, and Lidingö	7	Owners		7	0	0

### The Royal Hunting Period

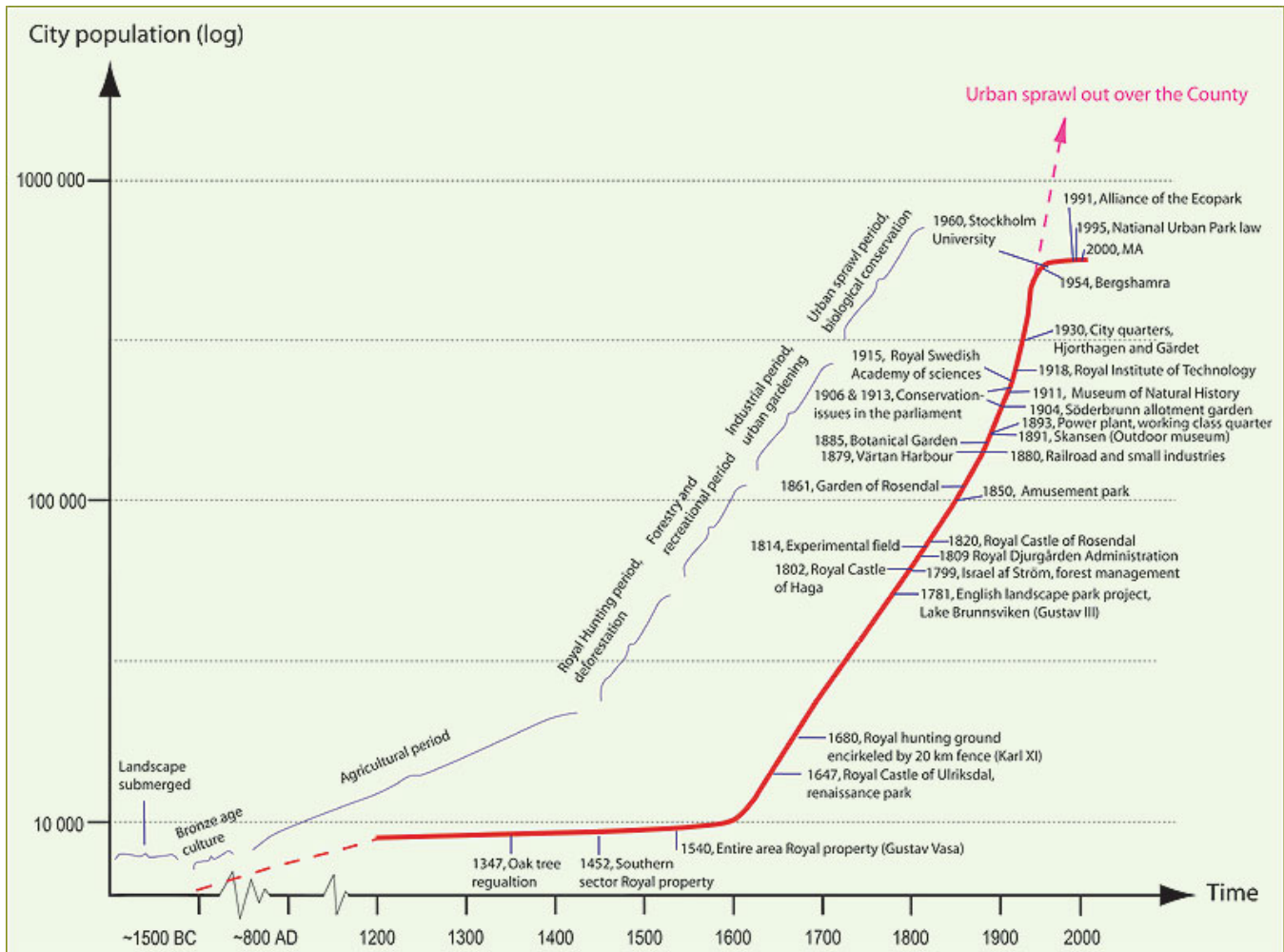
Agriculture was the dominant land use in the area until the end of the 1600s, when royal hunting became ever more fashionable. During this period, the ruling elite of Sweden was strongly tied to the Royal Court (Edlund 1991). Consequently, the nobility built their residences around Stockholm and in the region around Lake Mälaren, called “Mälardalen.”

In contrast to farmers of that time, who eradicated oak seedlings from their properties, oak populations found a refuge on the nobility’s country estates, mainly because the demand for oak wood for shipbuilding material for the Crown’s navy (Fogelfors and Hansson 1997). The contemporary NUP’s oak population, which includes trees that are several hundred years old, forms part of the population in the Mälardalen landscape, and is one of the major oak populations of northern Europe (Herdin 2002).

The predominant view of nature during the 1600s was that it should be pruned and controlled, to symbolize power and status (Frängsmyr 1984, Edlund 1991). The ideal was the royal park at

Versailles, with its mathematical formations and details influenced by antiquity. During this period, in the mid 1600s, a castle with a renaissance park was built in the “Ulriksdal” area (see Fig. 4). The castle was later transformed into a royal palace (Edlund 1991, Schantz 2002). In the 1690s, a large part of Djurgården was transformed into a royal hunting ground that was enclosed by a 20-km wooden fence to protect the royal game from predators and poachers (Brusewitz and Ekman 1995). Grazing inside the fence was intensive, partly because of the large numbers of deer and partly because of grazing livestock owned by farmers, who could pay an entrance fee (Lundevall 1997). In 1729, the number of deer was estimated to be more than 1500, resulting in even more intensive grazing pressure than that experienced during the agricultural period. In addition, theft of wood was common. Wood for heating was highly valued by the citizens during cold winters, because almost all the local forests had been harvested to produce charcoal for the ironworks (Stockholm Planning Administration 1997). All this culminated in the deforestation of the park (Lundh 1928), although the situation was estimated to be better inside the fence than outside due to the royal protection (Stockholm County Administration Board 1999). A

**Fig. 3.** Summary of key events shaping the relationship between the residents of Stockholm and the environment.



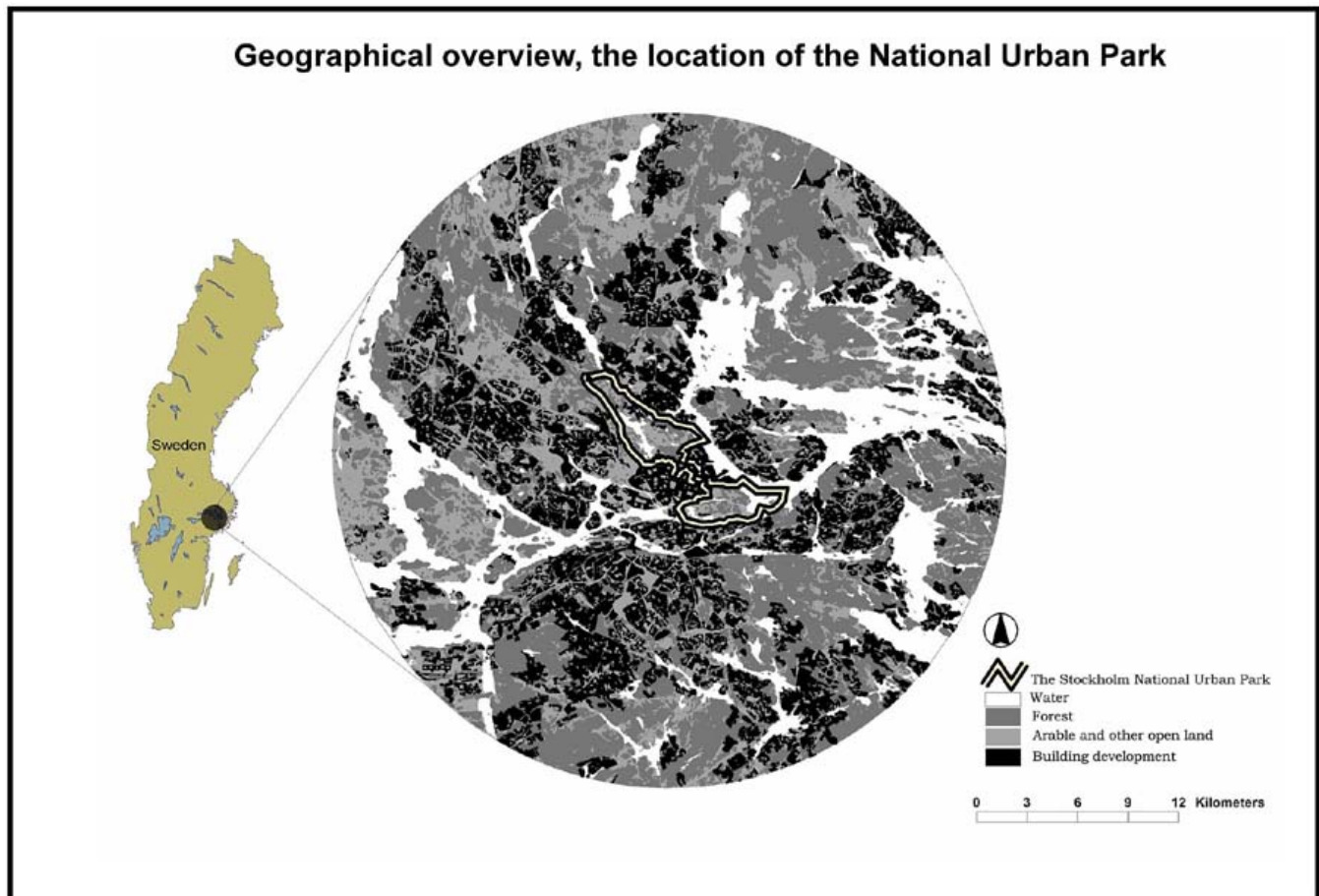
royal management agency, the Royal Djurgården Administration (in Swedish, “Kungliga Djurgårdsförvaltningen” (KDF); <http://www.djurgardskartor.lantmateriet.se/>), was established around 1809 to manage the hunting ground (Stockholm County Administration Board 1999), and it is still one of the main managers of the park ( <http://www.djurgardskartor.lantmateriet.se/> ).

### The Forestry and Recreational Period

There seem to have been two separate events that triggered a response to counteract deforestation. First, there was a conceptual change in the human–nature relationship during the 1700s, and second, the birth of modern forestry in Sweden occurred at the end the 18<sup>th</sup> century.

The change in the human–nature relationship was inspired by the English landscape park concept (cf. Johanisson 1984, cf. Edlund 1991, cf. Schantz 2002). The concept was based on romantic ideals, with a worldview of nature as divine. The landscape

**Fig. 4.** Geographical overview.



management objective during this time was to enhance the scenic beauty of the natural landscape, and not to prune nature as prescribed by the French ideal. With these ideals in mind, King Gustav III initiated a large English landscape park project around Lake Brunnsviken in 1781 (see Fig. 2).

Twenty years later, Israel af Ström became the chief forest officer of Djurgården. He perceived the forests of the park to be in a terrible state, and he was determined to radically enhance their condition (Lundh 1928). In the first half of the 1800s, af Ström established a forest institute for the dissemination of his ideas and nurseries that would generate trees for various planting projects. He also created what are thought to be the first written forest management

plans in Sweden (Slottsarkivet E1:5 1807), and he was particularly interested in oak, because of the high demand for it from shipbuilders (Herdin 2002). Israel af Ström's efforts received unexpected support as the project coincided with Sweden's installation of a French army marshal as King of Sweden. Jean-Baptiste Bernadotte became Karl XIV Johan and ruled Sweden from 1818 to 1844 (Lundevall 1997). The new King was fascinated by the landscape of the NUP and wanted it to resemble a continental landscape. At his initiative, a channel was constructed, and he built his summer residence, called "Rosendals slott" next to it (Lundevall 1997). The ideas of the new King and Israel af Ström shaped the area into a park-like landscape. Broadleaf and pine forests, alleys, and exotic tree species were

planted over large parts of the formerly overgrazed area, giving the landscape much of its character today (Lange 2000).

Ordinary citizens had been fenced out of royal parks and gardens until the 1700s. The main social drivers that led to a shift toward public use of the green space in Stockholm were the sevenfold population growth that took place during the 17<sup>th</sup> and 18<sup>th</sup> centuries, and international movements, such as the English landscape park concept and the French Revolution of 1789 (van Rooijen 2004). At the end of the 1700s, there were about 70 000 dwellers in a city that was notorious for its filth, stench, and disease ( <http://www.historia.su.se/urbanhistory/>, Edlund 1991, Nilsson 2000). During the 1800s, the park became the main recreational attraction for the residents. Recreational institutions such as, for example, an amusement park, a theatre, several museums, and an outdoor museum were established (Lundevall 1997). Up to 10 000 people a day from all walks of society would visit the area to walk, ride, eat, and dance. This trend of opening up parks for public use occurred simultaneously in several central European cities (van Rooijen 2004).

## The Industrial Period

The industrial revolution, initiated in the mid 1800s in Stockholm, imposed major changes in society that, in turn, had a long impact on the NUP. For example, the main harbor of Stockholm was built there, along with a railroad and adjoining station buildings and manufacturing industries. A gas-fueled power plant was also built, with its power lines cutting across the park (Lignell 1995). In addition, a working-class quarter was created—the forerunner of modern urban sprawl in the area, characterized by large-scale apartment building projects (Lundevall 1997).

One outcome of industrialization, probably in response to the process of migration from rural areas (cf. Nilsson 2000), was a demand for gardening. The Garden City, the Swedish allotment gardening movement, and the botanical gardens were created during this era. In 1814, the Royal Swedish Academy of Agriculture established an area for experimental agriculture in the park. Its purpose was to enhance agricultural production, according to the ideals of the industrial revolution. One hundred hectares were irrigated with ditches and turned into croplands, fruit orchards, and horticultural gardens

that were used for agricultural experiments. The area was called the Experimental Field (“Experimentalfältet”) (Lange 2000). Gardening grew steadily in the park, and in 1861, the Swedish garden association started cultivation at the “Rosendal” castle property. The garden association developed an immense variety of species of fruit trees, vegetables, and exotic plants, and educated 700 gardeners between 1862 and 1911 ( <http://www.rosendalstradgard.com/>). Additionally, in 1885, the Botanical Garden relocated from the growing city to the shoreline of Lake Brunnsviken. The land was converted to horticultural plantations, and various forest biotopes and a garden school were also established (Edlund 1991, Lundevall 1997).

At the turn of the 20<sup>th</sup> century, the population in the city of Stockholm exceeded 300 000 ( <http://www.historia.su.se/urbanhistory/>) and industrialization had led to poor living conditions for much of the lower classes. In Stockholm, the first allotment garden area was established in 1904 at Djurgården. Of particular importance in sparking the gardening movement in Sweden was the work of Anna Lindhagen, who became the first chairperson of the Association of Allotment Gardens in Stockholm, founded in 1906 primarily through her work. She was inspired by social–aesthetic ideas of the time and believed that humans could realize their full potential in an aesthetically attractive setting. In the 50-year period following the movement’s establishment in the park, another five allotment areas were created, areas that are still actively used as allotments (Lindhagen 1916, Nolin 2003, <http://www.koloni.org/pdf/01.pdf>).

## The Urban Sprawl Period

Urban sprawl, defined as suburban growth, ribbon development, scattered and leapfrog development (Couch and Karecha 2003), accelerated at the beginning of the 20<sup>th</sup> century in Stockholm, and led to the destruction of green space in the park. For example, the King at that time (King Oskar II) gave away land to friends for private residences, or to construct hospitals, military establishments, and schools (Lundevall 1997).

Community response to urban sprawl in the NUP began as early as 1906 and 1913, when the issue was raised in the Swedish parliament, and total protection of all unexploited land in the NUP was called for (Brusewitz and Ekman 1995; Lundevall

1997). However, this response was not particularly successful at stemming urban sprawl. Pressure increased as the population of Stockholm more than doubled during the first half of the century (see Fig. 4). Several major scientific centers were built between 1909–1918, such as the Museum of Natural History, the Royal Institute of Technology, the Royal Swedish Academy of Sciences, and later, Stockholm University (1960) (Edlund 1991, Norrby 2002). Moreover, increased demand for housing during the 1930–1970s resulted in the establishment of entire new city quarters, such as Hjorthagen, Gärdet, and Bergshamra. By the end of the 1970s, approximately one third of the surface area of the NUP was covered by pavement and buildings. Consequently, habitats that were formerly connected, now became fragmented (Lundevall 1997, Löfvenhaft 2002a). In the 1980s, plans for massive development that would destroy major historical and biological values in the park were made public. This time, society was ready to respond.

During the 1960s and 1970s, the public became more concerned about the environment, and a vital environmentalist movement was born (Lundqvist 1971, Boström 2001). Consequently, the development threats of the 1980s ignited a passionate response at all levels of the community. A network of informal associations comprising more than 175 000 members actively campaigned to protect the park (Waldenström 1995). This community response finally culminated in the enactment of the National Urban Park law in 1995. The NUP now enjoys legal status as an area of national interest. However, it is still under continuous pressure, and it remains to be seen whether the law can stem the tide of urban sprawl (Holm and Schantz 2002). Figure 4 summarizes the social–ecological development of the NUP and the key events, or mental models, that transformed the relationship between the residents of Stockholm and the environment.

### **BIOLOGICAL DIVERSITY—A RESULT OF THE CULTURAL LANDSCAPE**

The historical social–ecological development of the NUP has created a unique cultural landscape that is rich in terms of biodiversity. Few areas of equivalent size in Sweden show such a high species diversity. The NUP covers only about 1% of the region of Uppland, and is one of the most frequently visited

green spaces in Sweden, yet it hosts approximately 75% of all the species recorded in Uppland (Lundevall 1997, Brusewitz 1995). More than 1000 Lepidopteran species documented, 1200 Coleopteran species, and 250 bird species have been observed here. There are more than 60 red-listed insect species, of which 29 are threatened and 27 are vulnerable. Among fungi, 32 species are red listed. As well, more than 20 species of red-listed vascular plants, mammals, amphibians, reptiles, and fish can be found in the park (Löfvenhaft 2002a, Bråvander and Jakobsson 2003).

We propose at least three reasons for the high species diversity found in the NUP, all of which relate to past activities in land use and management. The first is the long continuity of royal land ownership throughout times of change in the surrounding areas. For example, grasslands and broadleaved forests are threatened biotopes in the Swedish landscape (Fogelfors and Hansson 1997, Löfvenhaft 2002a); the forest of the former royal hunting ground may be the best preserved in this part of Sweden because it enjoyed royal protection dating back many centuries (Brusewitz 1995). Because the landscape was strongly tied to royal land ownership, formal institutions and strong cultural traditions dedicated to its preservation were established.

The second reason, and perhaps most important, pertains to the long tradition of management policies that, over the years, have intentionally favored oak. The NUP has one of the largest populations of giant oaks in Europe, many of which were planted (Herdin 2002). About 25% of all tree species in Djurgården are oak trees (Bråvander 2003, Borgström 2003), some of which are at least 500 years old (Stockholm County Administration Board 1999). The oak is a keystone species in this geographical setting, producing a unique set of niches for flora and fauna dependent on old hollow trees (Ranius et al. 2001), and hosting up to 1500 other species of fungi, lichens, insects, birds, and bats (Hultgren et al. 1997). Of all red-listed insects 80% are linked to old-growth oak trees and lime trees (Gothnier et al. 1999). The large populations of oak make the park unique from an international perspective.

The third reason for the large number of species present in the NUP is that it contains many diverse biotopes (cf. Gothnier et al. 1999, Löfvenhaft 2002b). The 24 biotopes in the park (see Table 1),

including various kinds of forest biotopes, grasslands, and wetlands, give rise to a highly patchy landscape (Peters and Goslee 2000). The park's landscape contains habitat for species that may unintentionally be dispersed by Stockholm's residents (cf. Sjöberg 2002). A striking example is that some of the more charismatic nesting bird species in the NUP originated from ancestors that escaped from the park's outdoor museum (Brusewitz 1995).

The three reasons presented above all relate to human intervention or management (i.e., are confined to social dynamics, and more specifically, related to property rights, oak management, and land use). The long, royal tradition of management and conservation of oaks can, in this context, be seen as slowly changing social variables that have contributed to ecological resilience in the present-day landscape of the NUP (cf. Carpenter et al. 2001). In other words, the contemporary landscape and the current biodiversity status of the NUP seem to be the result of co-evolution, or self-organization through mutual training (Colding and Folke 1997) between people and nature (Costanza et al. 1997). Consequently, conservation of the rich levels of biodiversity still depends on human intervention.

## LOCAL STEWARDS AND STEWARDSHIP ASSOCIATIONS OF THE PARK

Historical review reveals that, over time, new actors became involved in the management of the area that today constitutes the NUP of Stockholm. The old tradition of royal land and government still continues, but has been supplemented, over time, by a much more diverse management structure that involves allotment areas and several recreational activities.

The contemporary bylaw-protected park is currently under serious pressure from urban sprawl as the Stockholm metropolitan area continues to grow, which has mobilized local groups to organize into lobbying organizations to counteract this pressure. In the next section we describe the result of the social inventory of local steward associations and their role in ecosystem management within the park.

## Local Stewardship Associations, Property Rights, and Management of Ecosystem Services

The Stockholm metropolitan area has witnessed a remarkable growth in stewardship and conservation groups that articulate strong values for different aspects of the NUP. Examples include sport clubs, allotment garden associations, and bird-watching clubs. Many are organized under the umbrella organization *Alliance of the Ecopark* (in Swedish "Förbundet för Ekoparken"), which consists of 50 volunteer associations comprising more than 175 000 members (<http://www.ekoparken.org/>). It was founded in 1991 in response to threats of vast developmental exploitation of the park. In 1995, the Alliance played a key role in securing legal protection for the park (Waldenström 1995, Wirén 2002).

Our inventory of local groups closely linked to the NUP identified 69 groups (Table 3). In Table 4, they are classified according to operational property rights, in accordance with Ostrom and Schlager (1996). A property right defines actions that individuals can take in relation to other individuals (Ostrom and Schlager 1996). Five bundles of operational-level property rights have been identified by Ostrom and Schlager (1996), including the right of *access* to an area or to the resource base as an *authorized entrant*; the right of *extraction* in order to obtain resource units, as an *authorized user*; the right of *management* to regulate internal use patterns and transform the resource by making improvements, as a *claimant*; the right of *exclusion* in determining who will have an access right and how that right may be transferred, as a *proprietor*; and the right of *alienation*, determining the right to sell or lease property, as an *owner*. Thus, an owner possesses all five of the above rights in a resource management system, whereas an authorized entrant only holds one, i.e., the right of access.

As can be concluded from Table 4, there are 44 authorized users in the NUP with limited rights to enter the area and extract resource units in accordance with what is allowed by the owners and by Swedish law. Examples include the local historical association of Djurgården, the Haga Boating Club, the Friends of Haga Brunnsviken, and the Association of authorized guides of Stockholm. Furthermore, there are 25 stewardship associations that manage the various locales in the NUP (see Fig. 5). In theory, they all hold management rights in the

**Table 4.** Property right regimes, bundle of rights, and level of governance among local stewardship associations active in the Park

Property right regime	Bundle of rights	No. of associations	Level of governance			
			Global	National	Regional	Local
Users	Access & withdrawal	44		3	2	39
Claimants	+Management	5	1		1	3
Proprietors	+Exclusion	13			1	12
Owners	+Alienation	7		7	0	0

area. Five hold only the right of management, i.e., they may be considered as claimants. These five include the World Wildlife Fund (WWF), a conservation organization that is active in a wetland grazing project, and the Swedish Society for Nature Conservation, Stockholm County (SNF), which is active in haymaking projects, oak planting projects, and the restoration and management of water bodies.

Thirteen of the 25 stewardship associations hold the additional right of exclusion, and may be considered proprietors. The [Royal Djurgården Administration](#) (KDF) is a key proprietor because it manages about 80% of the ecosystems within the NUP, including most of the oak population (Herdin 2002, Borgström 2003). In their current management plan, from 1992–1993, the main purpose of management is to secure the continuity of the natural and cultural environment, and within this framework, also to meet the recreational needs of visitors.

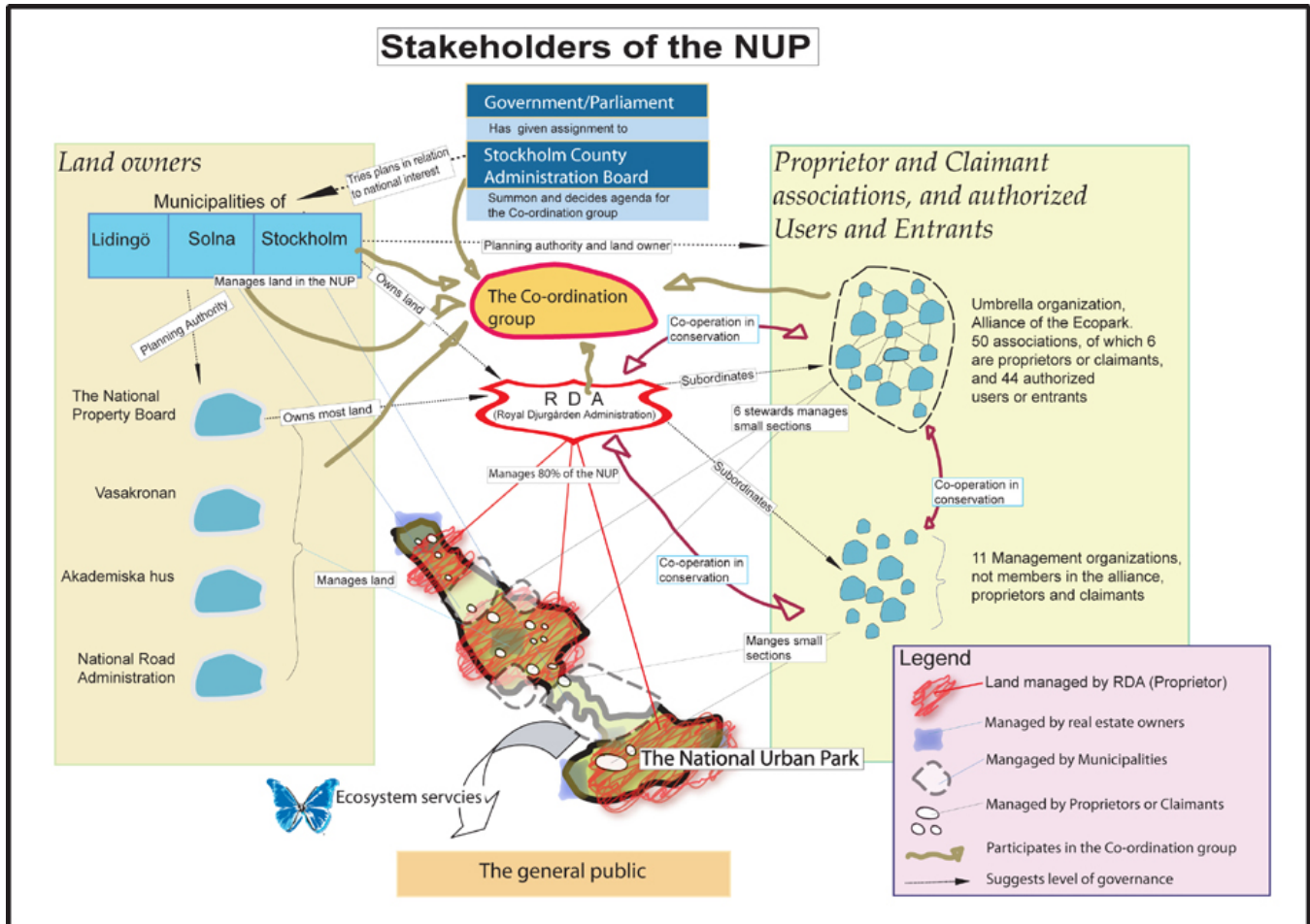
Another important proprietor is Stockholm Water Inc. (“Stockholm Vatten AB”), which manages the NUP’s water courses, lakes, and wetlands. Its main objectives are to restore wetlands and decrease polluted inflow from urban surroundings (Stockholm Environmental and Health Administration 1994). Urban gardens and six allotment gardens within the NUP are classified as proprietors because they hold the right of exclusion.

Seven of the 25 associations also hold the additional right of alienation, i.e., may be considered owners.

The National Property Board (“Statens Fastighetsverk”) owns most of the land in the NUP and is responsible for its long-term maintenance. It is also involved in some direct management activities, although the [KDF](#) manages most of their holdings. Other key landowners in the NUP are the municipalities of Stockholm and Solna. The municipality of Stockholm acts both as a land developer responsible for the land-use planning through the Stockholm City Planning Administration, and with park maintenance through the Real Estate and Traffic Administration. The municipality of Solna has a similar dual structure. These dual roles of the municipalities may increase their risk of conflict of interests in decision making and planning.

Furthermore, the authorized users and local stewardship associations of the NUP exist at various levels of government, from local to regional to national and even international levels (see Table 3). However, most operate at the local level. Of the claimants, the WWF operates at an international level and the SNF at a regional level. The locally evolved claimants are the Stockholm Bird Watching Club, a fishing association called “Patrullen Utter,” and the Association of Bergshamra for All (“Bergshamra för alla”). Like these, most of the proprietors have evolved locally, and only Stockholm Water Inc. operates at the regional level. Land ownership in the NUP is overwhelmingly in the hands of the state [although there are quite a few detached houses that are privately owned in the NUP, but the local homeowners have not previously been analyzed].

**Fig. 5.** The governance system of the National Urban Park, including stewards and stewardship associations with different operational property rights



Continuous active management is crucial to sustain the biological values and associated ecosystem services in this cultural urban landscape. In Table 2, we present the first tentative results of an analysis of the different stewards and local stewardship associations of the park in relation to the habitats and ecosystem services (Daily et al. 1997) with which they are connected. Not surprisingly, most stewards are involved with recreational services. What is more surprising is the number of stewards who take part in managing habitats that have the potential to support seed dispersal and pollination, and to serve as genetic banks. Hence, continuing inclusion of many local stewards in the governance of the NUP may play an important role in sustaining

the flow of these ecosystem services. This role of local stewardship associations has long been overlooked in resource and ecosystem management, but is increasingly appreciated and may play a central role in adaptive co-management and governance. However, there may be potential trade-offs between different ecosystem services delivered from the NUP, because of the vast number of local stewards involved in management. One example is the trade-off between public recreational values and the support services offered by allotment gardens. Allotment gardens are fenced-off areas for horticulture that prohibit horseback riding or dog walking and some other public recreational services. On the other hand, these small-scale



gardens provide supporting ecosystem services with cross-scale links to the larger ecosystem, such as pollination, seed dispersal, and insect pest regulation.

## DISCUSSION

In our historical account, we described the development of contemporary NUP, and stated that the park's landscape and its rich biological diversity are a result of social–ecological interactions and co-evolution. Given that humans have continuously exploited the area with diversified and intensified land uses with time, the park's ecosystems have been strongly influenced by societal changes. There was no pre-human period in the area—it was transformed into an agricultural landscape as soon land-upheaval processes provided human settlers with fertile fine sedimentary soils. Gradually, it was expropriated by royalty because of its fertile soils and proximity to Stockholm, and it became valued for its suitability as a hunting ground, and later, for its esthetic values. Throughout history, the area was managed by royal initiatives according to varying ideals. Over time, city dwellers began to benefit from the area for recreational green space. During the last 200 years, land use in the area has diversified. It seems that the period before industrialization mainly caused temporary potential crises in ecosystems in contrast to more permanent habitat destruction such as construction of city quarters and other establishments (see Fig. 4).

In areas experiencing rapid social and environmental transformations, such as Stockholm County, there is a need to develop a social capacity for urban ecosystem management to respond to change, and to develop policy directions that can help build resilience to deal with further change. Berkes et al. (2003) refer to such a capacity as “adaptive capacity.” As the theories on common property systems (Ostrom and Schlager 1996, Ostrom 1998) and complex adaptive systems (Levin 1998) indicate, adaptive capacity is constrained by social institutions and the resilience of the natural systems on which they depend (Berkes et al. 2003).

A crucial part of building adaptive capacity is a governance system that can learn from experience and generate knowledge across organizational levels. Institutions and their links (both vertically and horizontally across organizational levels, and involving local people, scientists, and authorities)

appear crucial in this regard because they promote information exchange to effectively deal with change and issues that transcend locality (Folke et al. 2003).

The simplest kind of cross-scale institutional link is one that connects local-level management with government-level management in partnerships, e. g., co-management (Pomeroy and Berkes 1997, Berkes et al. 2000). Co-management designs have the potential to lower overall costs of management, most notably costs incurred for describing and monitoring the ecosystem, designing regulations, coordinating users, and enforcing regulations (Hanna 1998, Johannes 1998). Also, the active involvement of citizens (through, e. g., local Agenda 21 activities) may be facilitated through co-management designs. Thus, the potential of co-management designs is well worth exploring for urban ecosystem management as well (Colding et al., in preparation).

Adaptive co-management has been suggested as an expansion of co-management to include adaptive management perspectives and actions as well (Olsson et al. 2004). Adaptive co-management systems are flexible systems of resource management tailored to specific places and situations and supported by, and working with, various organizations at different levels. Folke et al. (2002) define adaptive co-management as a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of learning-by-doing. The sharing of management power and responsibility may involve multiple institutional links among users, local stewardship association, government agencies, and non-governmental organizations (NGOs) (Olsson et al. 2004).

### **The Prospects for Adaptive Co-management of the NUP**

Although an institutional analysis of this kind requires further research, nevertheless we would like to highlight some key points of this organizational web that largely serves as an analysis of some preconditions important for adaptive co-management. Institutional theory normally assumes that ownership of land creates the strongest incentives for promoting the efficient use of property because it creates incentives for not misusing land, thus the value of the land is likely to

increase over time. On the other hand, and as we argue here, owners may wish to sell land, and thus turn productive land into real estate. Also, owners may terminate land-lease contracts, and thus change land use. All these characteristics render owners the most influential of the local stewardship groups of the NUP. Although ownership may promote the efficient use of property, empirically conducted institutional studies suggest that it is not a necessary outcome, and that proprietors can also make decisions that promote long-term investment in and harvesting from a resource (Ostrom and Schlager 1996).

Even so, if collective-choice arenas exist, empirical studies suggest that even authorized users, such as sport-fishing associations, can influence decisions regarding management and exclusion; therefore, such arenas have the potential to create incentives for sustaining the capacity of ecosystems to generate services. Collective-choice arenas entail that most individuals affected by operational rules are included in a group that can modify these rules (Ostrom 1990). Such arenas can involve settings that are not official legislative or judicial settings (Ostrom and Schlager 1996), but can be developed through local self-organization, in which participation can promote conflict-resolution processes and provide mechanisms to back up local monitoring and sanctioning efforts.

In the case of the NUP, the Swedish Government has placed the overarching responsibility for its protection on the [Stockholm County Administrative Board](#), operating at the regional governance level. The board has the authority to prohibit plans that violate regulations concerning the protection of the park, and it has the responsibility to coordinate all stakeholders involved in the NUP, in what is called “the coordination group.” The aim is to exchange information, settle conflicts, and develop a common management plan for the NUP. A number of stewards and conservation groups that articulate local values of the park participate in the group (see Fig. 5). However, conflicts of interest and tensions have arisen in this top-down structure, to some extent due to different perceptions and perspectives on urban development vs. conservation values of the park (Wirén 2002). Wirén (2002) also detected numerous conflicts between associations within the coordination group due to trade-offs between the interests of the various players and holistic recreational and biological values of the NUP.

Moreover, dialogue among the various proprietors and owners about practical management is currently limited (Borgström 2003). Thus, conflicts and limited dialogue are deficits that slow down cross-level interactions among stakeholders. For instance, the key water manager, Stockholm Water Inc., is not represented in the coordination group, although water bodies and wetlands are ecologically connected to the rest of the landscape.

As the social inventory reveals, there are as many as 69 stakeholder groups directly and indirectly involved in the management of the NUP. We have found that several of these seem to be stewards of urban green habitats that generate valuable ecosystem services (Table 2). The locally self-organized user and interest groups of the NUP may be suitable candidates to participate in monitoring the effects of pilot management projects. People in these organizations have often been active in the area for decades, which presumably gives some of them experience in managing local resources and ecosystems. Moreover, because their time spent in the locale is on a volunteer basis, monitoring is likely to be highly cost effective. There should be a potential to develop an ecosystem-based management approach to the NUP, involving those stewards in ecosystem management and restoration. It could follow an adaptive co-management approach.

As argued by Ruitenbeck and Cartier (2001), co-management is an emergent property of resource management systems, not an arrangement that should be top-down legislated, but one that develops spontaneously. However, it needs to be framed by higher-level institutions, what Folke et al. (2003) refer to as framed creativity. Olsson et al. (2004) argue that conditions can be created to facilitate the emergence of adaptive co-management systems. These include enabling legislation that creates social space for ecosystem management, providing funds for responding to environmental feedback, facilitating information flow through social networks, combining various sources of information and knowledge, sense-making between knowledge traditions, and establishing arenas for collaborative learning of ecosystem management. These conditions reflect cross-scale dynamics of adaptive co-management and involve the roles of key individuals and trust building throughout the process.

We suggest that several of the above conditions already seem to exist in the NUP, such as

institutional space, funding possibilities, and existence of arenas for collaborative learning. As our social inventory indicates, there are horizontal links between local stewards of the NUP, as well as vertical links between different levels of government and governance. However, information flow and a social network for building ecosystem management still need to be developed. This may require increased coordination among local stewardship associations that are active in both the NUP and other green spaces in the Stockholm metropolitan region.

## CONCLUSIONS

Through our historical analysis, we have illustrated that human actions have shaped and generated the high level of biodiversity found in the NUP of Stockholm. The parks's biodiversity is a result of a cultural landscape with a long-term social memory of park management. The property rights of the area, in particular its function as royal land, have contributed to filtering short-term trends, and have prevented its transformation into an intensive production landscape. However, the rapid growth of the Stockholm metropolitan region now challenges the values of the park through urban growth and through increased isolation of the park in the broader green space landscape. In order to protect the park, legislation in 1995 gave the area status as an area of national interest. However, urban sprawl continues both inside and on the fringes of the park. A further step may be to turn the park into a nature reserve, as is currently proposed by some regional actors.

Although protected area management may be one way to go in urban areas, such an approach ignores the important aspect that active management by a considerable number of local stewards with a stake in ecosystem management has contributed to the high biodiversity levels presently existing in the park. The analysis indicates that the widespread involvement of stewardship associations may play a significant role in generating and sustaining socially valuable ecosystem services, such as recreation, seed dispersal, and pollination. Many of the local stewards manage the locales in the park on a voluntary basis, using different management practices.

The Swedish Government has given the [Stockholm County Administrative Board](#) the task

of developing an overall management plan for the NUP. Adaptive co-management may be worth exploring for the management of the NUP in this context, or at least for parts of the park. The 25 identified stewardship organizations with management rights operating in the NUP seem to be suitable candidates for participation. Policy makers should create incentives for coordinating these associations horizontally and with other levels of vertical governance in the park and of surrounding green spaces, including government agencies, such as municipalities, county administration, and concerned NGOs. It may increase the likelihood of sustaining the socially valuable ecosystem services of the Stockholm urban green spaces.

Responses to this article can be read online at:  
<http://www.ecologyandsociety.org/volXX/issYY/artZZ/responses/>

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APPENDIX 1. A list of websites and maps consulted for the purposes of this research, and details on interviews with stakeholders in the NUP

#### Websites

Alliance of the Ecopark: <http://www.ekoparken.org/>

Garden of Rosendal (Rosendals Trädgård). Home page, 2003-11-25: <http://www.rosendalstradgard.com/>

Millennium Ecosystem Assessment (MA): [www.millenniumassessment.org/](http://www.millenniumassessment.org/)

Royal Djurgården Administration (in Swedish, “Kungliga Djurgårdsförvaltningen”):  
<http://www.djurgardskartor.lantmateriet.se/>

Stockholm Urban Assessment (SUA-Sweden): [www.ctm.su.se/SummaryofStockholmUr/](http://www.ctm.su.se/SummaryofStockholmUr/)

Stockholm County Administration Board: [www.ab.lst.se](http://www.ab.lst.se)

Stockholm University, Center for Transdisciplinary Environmental Research: Homepage, 2004-11-20.  
[www.ctm.su.se/SummaryofStockholmUr/](http://www.ctm.su.se/SummaryofStockholmUr/)

Stockholm University, Department of History. Illustration of population dynamics of the city, 2003-11-07:  
<http://www.historia.su.se/urbanhistory/cybcity/sthlm/befolk.htm>

Swedish Allotment Union. Homepage, 2003-11-07: <http://www.koloni.org/pdf/01.pdf>

#### Maps

**Löfvenhaft, C., and Lannek, J.** 2002. *Biotope map of Stockholm*. Älvsby Tryck, Älvsby, Sweden.

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#### Interviews

Opperud, I. M. Chairwoman of the allotment association of Söderbrunn and member of Alliance of the Ecopark. 2003-05-28.

Schantz, P. Vice chairman of Haga-Brunnsvikens vänner and board member of Alliance of the Ecopark. 2003-03-22.

Waldenström, H. Member of the board of the Alliance of the Ecopark, part time employe of WWF and member of Stockholms Ornitologiska förening. 2003-04-09.

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## APPENDIX 2. Organizations and associations that are linked to the National Urban Park

Management Organization	Main Aim of Activity	Management Locale & Objective	Associated Property Right
<b>Global Level</b>			
World Wildlife Foundation	Maintenance of culture and biodiversity	Restoration of the wetland of Fisksjöäng & high land cattle project	Claimant
<b>National Level</b>			
National Property Board	Maintenance of culture and biodiversity	Maintenance of the Royal palaces and parks of Ulriksdal, Rosendal, and Haga, as well as the Islets of Skeppsholmen and Kastellholmen.	Owner
Swedish National Road Administration	Build and maintain roads and highways	Roads and highways in the park	Owner
Vasakronan	Real estate owner	Management of Sörentorp, park management	Owner
Municipality of Stockholm	Maintenance of culture and biodiversity	Maintenance of Bellevue, the Royal Institute of Technology and the City quarters of Gärdet and Ekhagen	Owner
Municipality of Solna	Maintenance of culture and biodiversity	Maintenance of Tivoli, Haga södra, Frösundavik, and the city quarter of Bergshamra	Owner
Municipality of Lidingö	Maintenance of culture and biodiversity	Maintenance of the islets of Fjäderholmarna	Owner
Akademiska hus	Real estate owner	Management of the green space around "the Science City." Clearing of land and park management	Owner
<b>Regional Level</b>			
The Swedish Society for Nature Conservation, Stockholm County (SNF)	Maintenance of biodiversity	Haymaking, oak planting, maintenance of ponds and nesting boxes in the park	Claimant
Stockholm Water Inc.	Decrease eutrofication and pollution	Restoration and maintenance of wetlands and water bodies	Proprietor
<b>Local Level</b>			
Royal Djurgården Administration (KDF)	Maintenance of culture and biodiversity	Maintenance of about 80% of NUP	Proprietor
Botanic Garden of Bergius	Demonstrate biodiversity	Gardening and bee keeping	Proprietor
<a href="#">The 4H Farm of Stora skuggan</a>	Education/recreation	Gardening, grazing, and bee keeping	Proprietor

Patrullen Utter	Sport fishing	Stocking game fish in water body	Claimant
Outdoor museum of Skansen	Education/recreation	Maintenance of the miniature cultural landscapes of Sweden, gardening and park management	Proprietor
Allotment area of Söderbrunn	Cultivation/recreation	Gardening	Proprietor
Allotment area of Kvarnvreten	Cultivation/recreation	Gardening	Proprietor
Allotment area of Frescati	Cultivation/recreation	Gardening	Proprietor
Allotment area of Jakobsdal	Cultivation/recreation	Gardening	Proprietor
Bergshamra för alla	Maintenance of culture and biodiversity	Haymaking and tree cutting at Tivoli	Claimant
Allotment area of Bergshamra	Cultivation/recreation	Gardening and maintenance of the commons	Proprietor
Garden of Rosendal	Biodynamic cultivation	Gardening, park management, and organic cultivation	Proprietor
<a href="#">Stockholms Ornitologiska förening</a>	Recreation/bird watching	Restoration and maintenance of nesting boxes and bird habitats	Claimant
Allotment area of Stora Skuggan	Cultivation/recreation	Gardening	Proprietor
Cemetery of Ulriksdal, Solna Kyrka	Burials	Lime-tree planting, haymaking, nesting boxes for small birds	Proprietor
<b>User Organization</b>			
<b>National Level</b>			
Friskis och svettis	Recreation and sport	N/A	Authorized user
Fältbiologerna	Biodiversity conservation	N/A	Authorized user
<a href="#">Svenska Cykelsällskapet</a>	Recreation/biking	N/A	Authorized entrant
<b>Regional Level</b>			
Friluftsförbundet, stockholm	Outdoor sport	N/A	Authorized entrant
Saltsjöbadens Naturskyddsförening	Biodiversity conservation	N/A	Authorized entrant
<b>Local Level</b>			
Albano Båtklubb	Recreation/boating	N/A	Authorized user

Föreningen äventyrarna	Recreation/adventure	N/A	Authorized entrant
<a href="#">Stockholms Orienteringsförbundet</a>	Orienteering	N/A	Authorized user
<a href="#">Svenska Turistföreningen Stockholmskretsen</a>	Lobbying	N/A	Authorized entrant
Djurgårdens -Lilla Värtans miljöskyddsförening	Lobbying	N/A	Authorized user
Djurgårdens Hembygdsförening	Culture conservation	N/A	Authorized user
Haga brunnsvikens vänner	Lobbying	N/A	Authorized user
Haga Båtklubb	Recreation/boating	N/A	Authorized user
Segelsällskapet Brunnsviken	Recreation/boating	N/A	Authorized user
Segelsällskapet vega	Recreation/boating	N/A	Authorized user
Stallmästaregårdens båtsällskap	Recreation/boating	N/A	Authorized user
Mellan Järva stallet, 85 15 62	Horseback riding	N/A	Authorized user
Ulriksdals hembygdsförening	Lobbying	N/A	Authorized user
Symbios	Lobbying	N/A	Authorized entrant
Kommittén Gustavianska parken	Lobbying	N/A	Authorized user
Samfundet St Erik	Lobbying	N/A	Authorized user
Hembygdsföreningen å Norrmalm	Culture conservation	N/A	Authorized user
Hembygdsföreningen östermalm	Culture conservation	N/A	Authorized user
Hyresgärföreningen Norrmalmsavdelningen	Lobbying	N/A	Authorized entrant
Naturskydds föreningen Sollentuna	Biodiversity conservation	N/A	Authorized entrant
Naturskydds föreningen i solna sundbyberg	Biodiversity conservation	N/A	Authorized entrant

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Norra Djurgårdens vänner	Lobbying	N/A	Authorized user
Norra Järva hembyggsförening	Culture conservation	N/A	Authorized user
Picknick-klubben	Recreation	N/A	Authorized entrant
Föreningen ekhagen	Lobbying	N/A	Authorized user
Bellevueförbundet	Lobbying	N/A	Authorized user
Bergianska trädgårdens vänner	Economical support to the botanical garden and to FFE	N/A	Authorized user
Kommitén för Gustavianska parken	Lobbying	N/A	Authorized user
University of Stockholm	Education	N/A	Authorized user
Stockholms fältridklubb	Horseback riding	N/A	Authorized user
Friluftsförbundet, Norra Järva	Outdoor sport	N/A	Authorized entrant
Föreningen Stockholms auktoriserade guider	Guiding	N/A	Authorized entrant
Stockholm marathon	Recreation/running	N/A	Authorized user
Stockholms Vandrarförening	Recreation/trekking	N/A	Authorized entrant
Föreningen natur och samhälle	Biodiversity conservation	N/A	Authorized entrant
Södermalmsparkernas vänner	Lobbying	N/A	Authorized entrant
Vårt Stockholm	Lobbying	N/A	Authorized entrant
Sofia Hembyggsförening	Culture conservation	N/A	Authorized entrant
<a href="#">Svenska Turistföreningen</a> <a href="#">Stockholmskretsen</a>	Lobbying	N/A	Authorized entrant

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## MEASURING SOCIAL–ECOLOGICAL DYNAMICS BEHIND THE GENERATION OF ECOSYSTEM SERVICES

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**Abstract.** The generation of ecosystem services depends on both social and ecological features. Here we focus on management, its ecological consequences, and social drivers. Our approach combined (1) quantitative surveys of local species diversity and abundance of three functional groups of ecosystem service providers (pollinators, seed dispersers, and insectivores) with (2) qualitative studies of local management practices connected to these services and their underlying social mechanisms, i.e., institutions, local ecological knowledge, and a sense of place. It focused on the ecology of three types of green areas (allotment gardens, cemeteries, and city parks) in the city of Stockholm, Sweden. These are superficially similar but differ considerably in their management. Effects of the different practices could be seen in the three functional groups, primarily as a higher abundance of pollinators in the informally managed allotment gardens and as differences in the composition of seed dispersers and insectivores. Thus, informal management, which is normally disregarded by planning authorities, is important for ecosystem services in the urban landscape. Furthermore, we suggest that informal management has an important secondary function: It may be crucial during periods of instability and change as it is argued to promote qualities with potential for adaptation. Allotment gardeners seem to be the most motivated managers, something that is reflected in their deeper knowledge and can be explained by a sense of place and management institutions. We propose that co-management would be one possible way to infuse the same positive qualities into all management and that improved information exchange between managers would be one further step toward ecologically functional urban landscapes.

*Key words:* ecosystem services; functional groups; institutions; local ecological knowledge; management; sense of place; urban ecology.

### INTRODUCTION

Social and ecological systems are interlinked and their separation is arbitrary when analyzing sustainable use of natural resources (Berkes and Folke 1998). The linkages between management and ecological processes have often been approached qualitatively, but very few, if any, studies actually quantify effects of ecosystem management on the generation of ecosystem services, which we do in this article. While the relationship between social features and ecosystem services could be studied in any social–ecological system, we have chosen urban green areas because cities have qualities that make them especially interesting, e.g., the human dominance and profound importance of human activities (e.g., Collins et al. 2000, Grimm et al. 2000). The aim of this article was to determine whether superficially similar urban green areas can be treated as uniform or if management matters. Further, the links between institutions, local ecological knowledge, and management practices and their connection to the delivery of three ecosystem services is analyzed.

About half of Earth's human population today lives in cities, and the proportion is increasing (United Nations 2005). This generates a tremendous pressure to develop urban green areas for alternative land-uses. However, there are strong arguments for their preservation: Urban green areas generate many ecosystem services that contribute to human well-being (Daily 1997, Chiesura 2004) and provide habitat for many organisms (see, e.g., Saure 1996, Tommasi et al. 2004). These services could also potentially help mitigate the growing disconnection of urban residents from nature (Pyle 1978, 1993). Cities today influence the use of natural resources globally (Folke et al. 1997, Alberti et al. 2003), and to gain the much needed, broad-based public support for a sustainable use of ecosystems, inside and outside cities, the places where people live and work need to offer opportunities for meaningful interactions with functioning ecosystems (Miller 2005).

We focused on three types of green areas in the urban landscape of Stockholm, Sweden: cemeteries, city parks, and allotment gardens. These three types of green areas were chosen as they are well-defined green, open spaces of comparable age and size while clearly different in their organization. City parks are included in urban green plans, while the other two are not. Cemeteries are usually owned by the Church of Sweden, and most city

TABLE 1. The sizes and approximate dates of establishment for the 12 study sites in Stockholm, Sweden, and impervious surface (IS) within a 300-m radius.

Study site	Size (ha)	Date established	IS (%)
Allotment garden 1	1.56	1917	39.9
Allotment garden 2	5	1905	39.2
Allotment garden 3	2.5	1954	11.2
Allotment garden 4	6.46	1915	17.2
Cemetery 1	5.3	late 19th century	19.8
Cemetery 2	2.41	~1780	20.5
Cemetery 3	9	1920	26.5
Cemetery 4	5.7	15th century	76.1
City park 1	9.37	1936	34.3
City park 2	4	1840	65.0
City park 3	5.18	~1880–1930	54.8
City park 4	11	17th century	37.9

parks are owned by the government, while allotment gardens are areas reserved for horticulture where plots of land are leased to individuals. Cemeteries and parks are managed by salaried managers, often alone, while allotment gardeners are organized in associations, with elected chairmen and committees. Individual allotment gardeners share obligations and regulations for the management of the whole area, but manage their own plots relatively independently and on a voluntary basis.

Management practices are partly constrained or enabled by social institutions and by the level of local ecological knowledge (LEK; Berkes and Folke 1998, Berkes et al. 2000). LEK is used here as knowledge held by an individual or a specific group of people about their local ecosystem, and the concept of institutions is used as the accepted rules and norms adopted by individuals and used within and across organizational settings (Ostrom 2003). It has been suggested that LEK generally is low among urban residents, but can be promoted by factors such as active land management and participation in outdoor recreation (cf. Theodori et al. 1998, McDaniel and Alley 2005). Sense of place is defined as an intimate emotional attachment to a place, created through firsthand interaction between humans and places (Kaltenborn 1998, Cantrill and Senacha 2001). Sense of place has been suggested to be a reliable predictor of how people will react to environmental impacts, as those with strong attachment to a place seem more committed to learn about and actively respond to negative change, which, in turn, enhances the emotional bond of these stewards to that place (Kaltenborn 1998, Oreszcyn and Lane 2000, Rogan et al. 2005). Thus, we hypothesized that the differences in organization and the degree of freedom in decision-making between the green areas would lead to differences in the managers' sense of place and willingness to increase their local ecological knowledge and respond to environmental feedback. If this is true, the corollary is that management practices should differ as well.

The ecosystem services were assessed indirectly through surveys of functional groups. The three groups were pollinators (bumble bees), seed dispersers (birds),

and insectivores (birds) (see Appendix A). They contribute, respectively, to the ecosystem services of pollination (Corbet et al. 1991, Buchmann and Nabhan 1996), seed dispersal (e.g., Robinson and Handel 1993, Sekercioglu et al. 2004), and pest regulation (e.g., Franz 1961, Mols and Visser 2002, Sekercioglu et al. 2004, Ellis et al. 2005). Birds and bumble bees are easily surveyed and are also organisms that most managers recognize and have some kind of emotional connection to.

Specifically, we tried to connect these different areas of research by addressing three questions: (1) To what extent do different management practices in the three types of urban green areas result in different patterns of species richness and abundance? (2) What are the possible links between urban species diversity patterns and ecological functions? (3) Are differences in management practices linked to the local social-ecological context of institutions, LEK, and sense of place?

#### STUDY AREA

The study used allotment gardens, cemeteries, and city parks within Stockholm County, Sweden. This is the most densely populated area in Sweden, with >2870 inhabitants/km<sup>2</sup> (SCB 2005), and a total population of 1.8 million people. Regional plans for green areas focus on 10 green wedges and transverse green corridors that are meant to constitute Stockholm's most important green areas. Parks are included in green planning and make up more than 1/10 of Stockholm Municipality's total (SCB 2005). There are also many other green areas, among them 10 000 allotment gardens occupying 210 ha of land and involving about 24 000 people (Björkman 2000, Moberg 2003, Nolin 2003). Many of them are located outside the wedges and corridors and thus not included in green planning. Allotment gardens in Stockholm are well-managed flower-rich areas differing in size (3450–70 000 m<sup>2</sup>) and spatial organization, from proper cultivation plots to more gardenlike plots with small houses and lawns. Cemeteries are another overlooked category of green areas, and cover ~250 ha. We chose four sites from each of the three categories as study sites (Table 1). The areas were chosen according to two criteria: age (older than 50 years) and size (approximately within 1–10 ha). Percentage of impervious surface (IS) within a 300-m radius from the study sites was measured as an indication of landscape context.

#### METHODS

##### *Pilot study*

The study started with a pilot study (cf. Patton 2002) of allotment gardens during spring 2003. The aim was to decide on how to bring together the different research fields into one study and to gather primary information about management practices, social institutions, ecological features in allotments, and finally, to outline the survey methods. The evaluation included 11 test interviews with randomly chosen allotment holders

and field observations in eight sites managed by allotment associations.

#### *Quantitative data*

We used species diversity and abundance of birds and bumble bees as indicators of ecosystem services. The species abundance and composition within a functional group are indirect measures of the performance of the ecosystem service, as they determine the efficiency of the ecological functions on which the ecosystem services are based (Chapin et al. 1997, 1998, Norberg 1999, Rosenfeld 2002, Kremen 2005). Information about bird diets comes from Cramp (1977–1994).

*Bird surveys.*—We collected data on the relative abundance of individual bird species at 12 point count locations, one in each of the study sites. Point locations were sampled four times during 2005, two times during winter and two times during the breeding season, all in the morning. We used a three-banded fixed-radius methodology, with the bands 0–25 m, 25–50 m, and >50 m, and a count duration of  $5 \times 2$  minutes (Gregory et al. 2004). All birds seen or heard were recorded, except those flying over the station as it was uncertain whether they used the area or not. Birds were categorized in functional groups according to their diet, and only the assemblages of seed dispersers (either hoarding granivores or frugivores) and insectivores were analyzed.

*Bumble bee surveys.*—Daylight surveys of bumble bees were conducted in May, June, and July during good weather. At each site, between 9 and 14 evenly distributed,  $3 \times 3$  m quadrats placed to contain species in flower were established. All bumble bees entering the quadrat during a 5-minute survey period (10 minutes in July) were identified to species according to Løken (1973), and the plant species visited recorded. Bumble bees were surveyed while foraging and the green areas' suitability as nesting sites was not assessed.

*Ecological data analysis.*—Since the number of samples and the number of bumble bee individuals observed differed among sites, an individual-based rarefaction was done with EcoSim 7.71 (Gotelli and Entsminger 2006). Individual-based rarefaction uses probability theory and the information provided by the collected species to estimate the mean species richness (Magurran 2004). Data from all sites were rarefied to 26 individuals, and the resulting estimate of species richness was used in the diversity analysis. Data on pollinator abundance was log-transformed before the analysis. Differences and/or similarities in community structure between the three types of green areas were described using non-metrical multidimensional scaling ordination (MDS; Clarke 1993). Differences were tested statistically using one-way analysis of similarities (ANOSIM) randomization test (Clarke 1988). Data was analyzed in two ways: either untransformed, using the relative abundances of different species, or presence–absence transformed to analyze the species assemblages.

Differences in species richness and abundance within each functional group, between sites, were analyzed using one-way ANOVA.

#### *Qualitative data*

The purpose with the qualitative approach (Kvale 1997, Patton 2002) was to analyze social features in relation to the three ecosystem services. The social features included management practices, institutions, local ecological knowledge, and sense of place held by managers and gardeners toward their respective areas. We used multiple forms of data in our methodological design: the pilot study, a survey, and semi-structured interviews. Only semi-structured interviews were used in cemeteries and parks.

*Survey.*—In 2004 and 2005, a questionnaire was sent out to all gardeners in four allotment associations, which made 532 respondents in total. The objective was to get information about management practices and local institutions and to identify key informants (people held to be especially knowledgeable about gardening and the local ecosystem [cf. Davis and Wagner 2003]) for the interview study. The purpose with identifying key informants for semi-structured interviews was to extract maximum information from a minimum of respondents (Patton 2002). More than two-thirds (68%) of the allotment holders responded (anonymously) to the questionnaire.

*Semi-structured interviews.*—Twenty-six semi-structured interviews were carried out. Fifteen were conducted with key allotment holders, as identified by the questionnaire, five with head managers of cemeteries, and four with managers of city parks. In addition, the head city gardener of Stockholm was interviewed for further information about her relationship with the interviewed park managers. The purpose of the interviews was to understand interviewee's (1) local ecological knowledge; (2) to identify key management practices and social institutions that have important implications for ecosystem dynamics, even if the linkages between these social features and ecosystem dynamics possibly was unknown to the respondents; and (3) to assess the emotional bond of the respondents to the area. Written questions (see Appendix C) were used as a guideline. These questions were open-ended (Kvale 1997), with the possibility to follow up clues that were revealed.

All interviews were recorded and transcribed; the length of the interviews varied between 60 and 90 minutes. The transcribed interviews were analyzed by classifying respondents' answers in relation to the topics of local ecological knowledge, of institutions, of practices, and of sense of place. Evaluation of local ecological knowledge was made by analyses of the respondents' answers to questions regarding site-specific abiotic conditions, interplay between organisms and these conditions, and interactions between organisms on multiple scales. The answers were compared to the scientific understanding of ecosystem dynamics in

TABLE 2. Average dissimilarities (Bray-Curtis) within each functional group between the different categories of green areas.

Functional group	City parks–cemeteries	City parks–allotment gardens	Allotment gardens–cemeteries
Insectivores	51.44	64.10	45.44
Seed dispersers	53.25	67.12	52.64
Bumble bees	30.23	35.49	32.38

cultural landscapes. The sense of place held by the respondents colored the answers and when emotions in relation to the area were revealed, they were followed up with additional questions.

#### RESULTS: INVENTORIES OF FUNCTIONAL GROUPS, MANAGEMENT PRACTICES, AND THE SOCIAL MECHANISMS BEHIND THEM

Allotment gardens had a much higher abundance of bumble bees than the two other types of green areas, and differences in community structure were found for seed dispersers and insectivores, which might be important if the functional groups were broken up in more detail. Diversity indices showed no differences between the different types of green areas. Management practices in allotment gardens clearly benefit bumble bees, and the difference between the areas seem to increase the total number of species, at least for insectivores. We identified 10 management practices of potential importance used among managers (see Table 3). Social mechanisms that structure management practices differ considerably between the three classes, evidenced by different types of protective norms, strength of emotional ties, and level of local ecological knowledge (see Table 4).

##### *Inventories of functional groups*

*Bird communities and species assemblages.*—No significant differences were found in species composition (species present; global  $R = 0.15$ ,  $P = 0.124$ ) or community structure (relative abundance of the different species; global  $R = 0.148$ ,  $P = 0.097$ ) between the three different types of green areas during winter. The community structure did, however, change with the type of green area during the breeding season (Table 2). The insectivore community structure differed between the three categories of green areas (global  $R = 0.523$ ,  $P = 0.003$ ). However, only allotment gardens and city parks differed significantly in the pairwise test (pairwise  $R = 0.813$ ,  $P = 0.029$ ). The species composition revealed another pattern: Only allotment gardens and cemeteries differed significantly (pairwise  $R = 0.344$ ,  $P = 0.029$ ). Based on the number of individuals of different species, the composition of seed dispersers differed between the three categories of green areas (global  $R = 0.332$ ,  $P = 0.012$ ). Again, only allotment gardens and city parks differed significantly in the pairwise test (pairwise  $R = 0.62$ ,  $P = 0.029$ ). The species composition itself showed no significant differences in the pairwise test (pairwise

$R = 0.182$ – $0.38$ ,  $P = 0.057$ – $0.143$ ). No statistically significant differences were found between sites for the species richness within either functional group.

*Bumble bee communities and species assemblages.*—In total, 755 bumble bee individuals from 14 different species were observed (Appendix A). Total number of species observed was higher in allotment gardens than in parks or cemeteries, but not significantly so. However, four species (*Bombus sylvarum*, *B. subterraneus*, *B. ruderarius*, and *B. norvegicus*) were only observed in allotment gardens. When the variation in number of bumble bee individuals observed was taken into account, we found no difference in species diversity between cemeteries, city parks, and allotment gardens (Kruskal-Wallis  $H = 0.50$ ,  $P = 0.779$ ) and there was no difference between bumble bee communities (global  $R = 0.088$ ,  $P = 0.229$ ) (Table 2). However, bumble bee abundance differed significantly between the three types of green areas (Fig. 1). Among the parameters measured, percent coverage of flowering plants was the one explaining most of the variation in bumble bee abundance ( $n = 12$ ,  $r = 0.88$ ; Fig. 2). These results were most influenced by the three most common species, *Bombus lapidarius*, *B. terrestris*, and *B. pascuorum*. When those three species were analyzed separately, they showed the same pattern as the total species assemblage. The other species observed were too uncommon to include in any meaningful single-species analysis.

##### *Management practices*

In order to compare areas and evaluate the management, we divided the effects of the practices into two types: protection and habitat improvement. Protection was further subdivided into total protection or protection of vulnerable life stages, and habitat improvement into food supply, structural complexity, soil quality, maintained or increased plant diversity, and well-being (Table 3). The quotes in the text reflect general perceptions within the different groups of managers.

*Management practices linked to seed dispersal and pest control.*—One example of specific practices that may affect the abundance and diversity of insectivorous birds was that 93% of the allotment gardeners (Survey A–D; all respondents and surveys can be found in Appendix B), all cemeteries, and all city parks (respondents 16–25) prohibit the use of pesticides. Managers in cemeteries and allotment gardens (27%; Survey A–D) provided birds with food, birdbaths, and nesting boxes. In



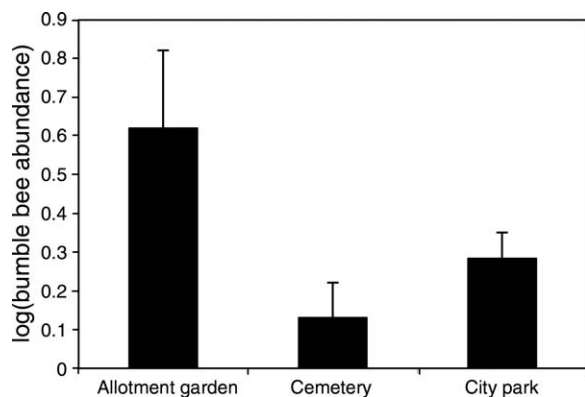


FIG. 1. Bumble bee abundance was significantly higher in allotment gardens than in both cemeteries and parks. There was no significant difference between parks and cemeteries. Error bars represent 95% confidence intervals.

allotments and cemeteries, care was also taken to protect small birds during vulnerable life stages, e.g., by preserving bird nests when trimming hedges (see Table 3). Winter-feeding was performed by 28% of the allotment holders (Survey 2004 and 2005) and, to some extent, in the cemeteries. The main targets were small birds, such as Blue Tit (*Parus caeruleus*) and Great Tit (*Parus major*), but this practice also favors other birds such as the Eurasian Nuthatch (*Sitta europaea*). One practice that seemed to be exclusively performed in allotment gardens was tilling of the soil, i.e., turning horse manure and dead plants into the soil, during early fall. Management practices that protect small birds or enhance their habitat seemed largely absent in city parks. The interviews with the park managers (Respondents 16–19) did reveal, however, that some practices such as winter feeding and, in one case, even putting up nesting boxes, were performed by visitors in some parks.

**Management practices linked to pollination.**—Managers, especially in allotment gardens, employed several practices that may affect living conditions for pollinating insects. The allotment gardeners' desire to have colorful flowers did increase the flower richness and the length of the flowering period, and many allotment gardeners (45%) intentionally plant flowers with the sole intent to attract pollinators. *Salix* spp., an important food source for early-flying bumble bee species, was also allowed to grow in the areas. Other practices linked to crucial life stages of bumble bees included provision and active protection of nests (Respondents 11 and 15). Practices linked to pollinating insects were found to be rare in cemeteries and city parks. Cemeteries had a higher total number of flowering plant species than parks, but there was no difference in mean coverage of flowering plant species ( $P=0.31$ ). The interviews further revealed that managers in cemeteries increase flower richness for prolonged periods compared to city parks in general, but they did not actively choose plants that attract pollinators (Respondents 21–26). Some of the

interviewed park managers did, on the other hand, plant flowerbeds with the sole aim of attracting butterflies (Respondents 16–19), even if these were very limited in size relative to the whole park.

**Sense of place, local ecological knowledge, and institutions.**—Allotment gardens can be seen as common pool resource systems (sensu Ostrom 1990), except for one important aspect: Allotment gardeners are not economically dependent on their garden plots. Instead, the most important driver for action seemed to be the sense of place, and all interviews reflected a strong emotional bond to their plots and the surrounding garden area (Respondents 1–15). The park managers were perhaps better described as planners; they interpreted the green plans and employed private enterprises to do the actual management. Compared to allotment gardens and cemeteries, where institutions were quite homogeneous, institutions structuring management of city parks in Stockholm showed large individual differences. These were partly ascribed to the different histories of the parks (Respondents 16–19). The relative strength of sense of place, LEK, and protective norms among different managers are shown in Fig. 3.

1. **Allotment gardeners' knowledge, institutions, and sense of place.**—It became evident during the interviews how strong the emotional bond between the gardeners and their plots was (Respondents 1–15). This bond was expressed differently; here is one example:

*This place is like an oasis for the soul. I get rid of stress and relax when I get here ... it is fantastic to see how they [the plants] can grow during a few months. It is fantastic.*

—Respondent 12

Local ecological knowledge in allotment gardens seemed to be based primarily on personal practice and

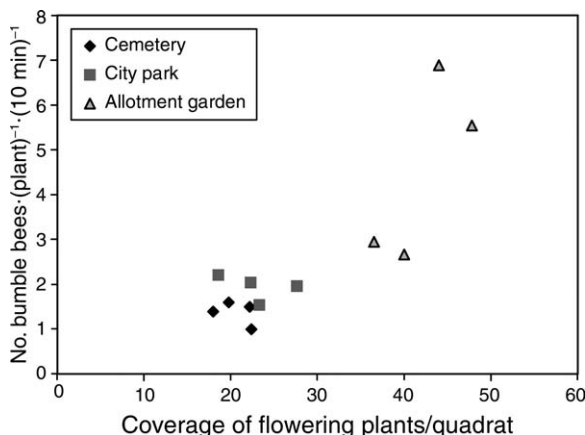


FIG. 2. Bumble bee abundance correlates with coverage of flowering plants. As can be seen, the abundances of flowering plants and bumble bees are significantly higher in allotment gardens. This indicates strong links between management practices in allotments and the ecosystem services of pollination.

TABLE 3. The table illustrates management practices (P, present; A, absent) in allotment gardens, cemeteries, and city parks of Stockholm and linkages to the ecosystem through their effect on functional groups.

Management practices	Functional group	Type of effect	Allotment gardeners (n = 378)	Cemetery managers (n = 4)	City park managers (n = 4)
Composting	decomposers, insectivorous birds	food supply, soil quality	P (68%)	P (25%)†	A
Winter feeding of birds	insectivores, herbivores, seed dispersers	food supply	P (28%)	P (50%)†	A
Enhancing habitats for small birds	insectivores, herbivores, seed dispersers	protection of vulnerable life stages, well-being	P (27%)	P (75%)†	A
Autumn soil digging	insectivores	food supply	P (?)†	P	A
Beekeeping	pollinators	protection of vulnerable life stages	P (?)†	P (25%)†	A
Organic gardening	decomposers, insectivorous birds	food supply, soil quality	P (93%)	P (100%)†	P (100%)†
Enhancing pollinator habitats	pollinators	protection of vulnerable life stages, food supply	P (45%)	A	P (50%)†
Active protection of natural enemies of pests (except birds)	predators of pests	total protection of certain species	P (?)†	P (50%)†	A
Prolonged flowering season	pollinators	food supply	P (?)†	P (100%)†	A
Active choice of plant species attractive to pollinators	pollinators	maintained/improved plant diversity	P (91%)	A	A

Notes: The values in parentheses indicate the percentage of respondents who perform the different management practices; a question mark indicates that the management practice was not included in the questionnaire, but was identified during interviews or from field observations. The sample sizes (n) reported in the column headings represent the numbers of respondents. For sources see Appendix B.

† Not included in questionnaire, but identified during interviews or field observations.

experience or that of fellow gardeners. Science-based knowledge was also present, as some use books and web pages of botanical gardens to gather knowledge (Respondents 1–15 and Survey A–D). The respondents had extensive knowledge of site-specific ecological processes (Table 4). Institutions and organizational aspects that constrain garden management in allotment gardens were the same for different areas, regardless of where in the city they are located. In Stockholm, local allotment associations often rent the land from the landowners for 25-year periods and are thus considered to be proprietors (cf. Ostrom and Schlager 1996). The associations have the right to exclude outsiders from their garden plots, but not to sell the land. They themselves decide on how to organize the management of the allotment gardens, and often it is the allotment associations themselves that enforce their own institutions (Respondents 1–15). The institutions were experi-

enced as intolerant by some gardeners, and all respondents shared experiences of plot holders being excluded from the associations.

*About the gardening rules, it is the board of this association that sets them. Once a year the board surveys all garden plots and if rules have been broken, the garden holder may ultimately be thrown out.*

—Respondent 7

Plants could be chosen freely, with the exception of a few plants that were prohibited by the associations. However, there were norms that urge garden holders to grow vegetables, fruits, berries, and traditional flowers (e.g., Respondents 6, 9, 12, and 13). These norms were evident since 91% of the gardeners *felt* that their neighbors wanted them to act in accordance with the norms. (Survey A–D, Appendix B). Other examples

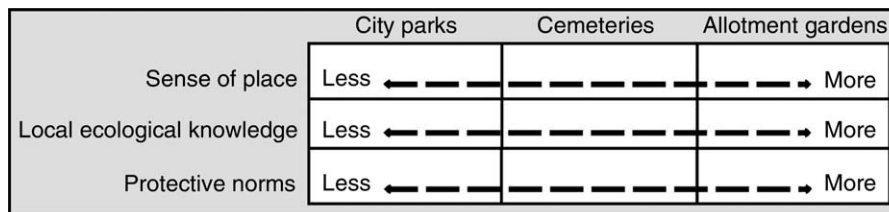


FIG. 3. The relative strength of sense of place, local ecological knowledge, and protective norms among the managers of different green areas in an urban setting.

TABLE 4. Examples of aspects of local ecological knowledge.

Knowledge about:	Allotment gardens	Cemeteries	City parks
Interactions between organisms	various predator–prey processes; pollinator–plant processes; competition processes; parasite–transmitter–host processes; critical life-stage processes	predator–prey processes; pollinator–plant processes; species as habitats to other species	parasite–transmitter–host processes; pollinator–plant processes; species as habitats to other species
Interplay between organisms and site specific abiotic conditions	crop rotation for enhanced harvest, avoiding disease, and fertilizing the soil; using decomposers as indicators of soil health and fertility; increasing microclimate for decomposers; interaction between microclimate and organisms	increasing microclimate for decomposers	
Spatial ecological processes	gardens as important feeding areas for pollinators from surrounding areas; spatial movements of species		

include distinct norms about environmental ethics and protection of pollinator species and small birds (Respondents 1–15). It was also common in allotment gardens to permit growers to keep beehives.

2. *Cemetery managers' knowledge, institutions, and sense of place.*—Ecological knowledge held by cemetery managers differed somewhat between the studied cemeteries. In general, ecological knowledge was partly based on local experience, but managers held knowledge that was different from the knowledge held by allotment gardeners: It was less comprehensive, as it was oriented more toward small birds and their function as predators of pests and less toward the role of pollinators and seed dispersers. Yet, they seemed to be aware that their cemeteries were relatively rich in flowers, and what that meant for pollinating insects. Cemetery managers expressed no clear sense of place during interviews (Respondent 21–25). Managers were constrained in their daily practices both by written regulations and a multitude of unwritten norms. Management practices were constrained by the funeral law, where the overall goal is successful interments, except for the more park-like sections of cemeteries where management was mainly structured by unwritten norms that seemed to have developed over long time periods (Respondents 21–25). All interviewed cemetery managers expressed the presence of unwritten norms for how to manage these areas. Here is one example of how this was verbalized:

*The funeral law is the regulation that we must follow; however, how to manage the green space in between the graves, we pretty much decide ourselves. . . . There are many unwritten rules that come from the long tradition of funerals.*

—Respondent 24

Some cemeteries outside the inner city allowed beehives. Yet, the most obvious social mechanism linked to the studied functional groups was that strict norms of protecting small birds were present in three-quarters of the cemeteries (Respondents 22, 24, and 25).

*We leave bird nests intact when we trim the hedges; we'd rather have irregular hedges than hurt the birds, and this is an unwritten rule here.*

—Respondent 22

3. *City park managers' knowledge, institutions, and sense of place.*—City park managers are employed by the city and their ecological knowledge varied greatly between different parks. Some park managers seemed to be quite ignorant of ecological processes in their parks, while others had academic education in ecology. In the latter cases, the kind of knowledge clearly differed from the knowledge in allotment gardens and cemeteries. It was often more general, and there was less knowledge about the linkages between the practices used and ecological processes in the area they manage. All city parks in our case study prohibited pesticides. No indication of sense of place was revealed during the interviews (Respondents 16–20). Head managers of city parks were restricted by physical plans and written regulations developed centrally by the Stockholm Land Administration (*Swe. Markkontoret*; Respondent 20). This was expressed by a city park manager in the following way:

*. . . our work is determined by a "bible" that we call the agreement. There everything is written down about what actions are to be taken and when.*

—Respondent 16



PLATE 1. Bumble bees benefit from the management practices used in allotment gardens. Photo credit: S. Barthel.

In some parks, cultural values were the prime concern for their managers, not the biological (Respondents 16–20).

#### DISCUSSION

##### *Main findings and evaluation*

Green areas such as allotment gardens and cemeteries are often overlooked in green plans developed by the City of Stockholm. However, as this study has shown, they generate important ecosystem services. We have demonstrated a method for examining the linkages between ecosystem services and management practices, institutions, knowledge, and sense of place. Differences in management practices had two consequences that may affect the provision of the different services: differences in the pollinator abundance (see Plate 1) and community structure of seed dispersers and insectivores, both of which set allotment gardens apart from the others.

*Interplay between birds and management practices.*—The two functional groups of birds differed in the relative abundance of different species between the three categories of green areas. Allotment gardens and parks seemed to share much the same seed dispersers but the relative abundance of the different species varied greatly. Most of the difference was made up by the abundance of a few species that were particularly favored in one type of green area, e.g., *Turdus pilaris*, which thrives in the lawn-dominated parks. We found no significant differences in species representation between the green areas. The pattern for insectivores was somewhat different as both species composition and relative abundance differed between the three types of green areas.

Cemeteries had somewhat different species than parks and allotments, but, as they did not differ from either parks or allotment gardens in community structure, the difference must be created by some of the less-abundant species. Instead, it was parks and allotment gardens that had significantly different relative abundance of different species. The result implies, however, that having different types of green areas increases the total number of insectivore bird species.

The results indicate that local managers, however well informed, have a limited influence over the functional groups of seed dispersers and insect pest regulators within their ambit. Moreover, the knowledge of ecosystem processes working on larger spatial scales seemed very limited (Respondents 1 and 10). As birds are known to respond to landscape as well as local factors (e.g., Hostetler 1999, Melles et al. 2003, Cannon et al. 2005), it might be argued that landscape factors are more important in shaping local species communities for these functional groups. Some of the management practices we had identified as potentially important, e.g., winter-feeding, did not show any effects in our results. As can be seen in Table 3, allotment gardens had the widest range of management practices that offer protection and improved habitat, which supports the hypothesized connection between sense of place and management. Many of these practices were also present in cemeteries, at least to some extent, but for other reasons: Here, institutions seemed to be the main social mechanism behind human interactions with birds. What was lacking in all study sites except one of the parks was management practices and knowledge that increased structural diversity, i.e., favoring many layers of

vegetation, which is very important for many birds (e.g., MacArthur and MacArthur 1961). The small scale of the studied areas suggests also that their management is most likely to affect small species such as warblers or tits (see, e.g., Hostetler 1999).

Interestingly, the norms protecting small birds in cemeteries and allotments might be linked to ecological processes, or disturbances, that act on longer time scales than those perceived by most gardeners, which are a couple of decades at the most (Respondents 1–15 and 21–25). These norms have some ecological consequences for system functioning during times of stability, as we have shown, but it may be during times of crises, such as pest outbreaks, that they are most ecologically important (Colding and Folke 2001). Thus, it seems that the local managers and their actions have two important functions: First, they influence ecosystem functions during periods of stability, and second, they might be crucial during periods of instability and change.

*Interplay between bumble bees and management practices.*—Species diversity and species assemblages of bumble bees were rather similar for the three types of green areas despite differences in management practices. Species diversity seemed to be affected by the proportion of green areas within the nearby surrounding landscape. Bumble bees are dependent on continuity of suitable flowering plants as well as good nesting sites within an area limited by their species-specific foraging ranges (Kearns et al. 1998, Osborne et al. 1999, Walther-Hellwig and Frankl 2000), which indicate that the landscape context could be of importance.

Bumble bee abundance differed significantly between the three types of green areas, and most of the variation was explained by the variable percent coverage of flowering plants, and to some extent, the number of bumble bee-visited plant species. Other management practices that appeared to be beneficial for pollinators were enhancing pollinator habitats, prolonged flowering season, and active choice of plant species attractive to pollinators; all mainly performed in allotment gardens (see Table 3). Abundance is important since it can affect the efficiency of the ecosystem service (Kremen 2005). Cemetery managers did create flower-rich areas, but seemingly without the intention to attract pollinators, and experienced knowledge about the pollinator–flower interaction seems to be limited. Cemeteries also lacked institutions protecting bumble bees (Respondents 21–25). In contrast, allotment gardeners seemed to be well aware of the mutual relationship between pollinators and flowering plants, as well as other ecological processes linked to the pollinator–flower interaction (Respondents 1–15). Such knowledge seemed to originate from the culture of keeping a kitchen garden in the old farming society and have been strengthened during the 100 years of allotment gardening in Stockholm (e.g., Respondents 8, 14, and 15; cf. Lindhagen 1916). In agreement with the quotes and statements from the qualitative interview studies, allotment gardens had

significantly more species of bumble bee-visited flowering plants than the two other areas and a significantly higher coverage of flowering plants in the quadrats surveyed. This indicates that in allotment gardens, management practices and their underlying social structures are favorable for the growth of bumble bee populations and of importance if we want to maintain the ecosystem service of pollination within the city. However, some management practices might serve to strengthen services under periods of stability but make the service more vulnerable to disturbance, e.g., beekeeping increases the total abundance of pollinators but may decrease the abundance of native pollinator species (Schaffer et al. 1983, Thompson et al. 2004), which would also have implications for plant communities by favoring honey bee-pollinated flowers.

*Methodological evaluation.*—The analysis might be weakened by the difficulty of finding replicates within a sufficiently similar landscape context. The surroundings of our study sites differ in the amount of green space vs. impervious surfaces, which makes the elimination of external factors difficult (see Table 1). We limited our study to address within-site conditions and would argue that the three types of green areas are reasonably distinct in terms of content and management. We did, however, discover that the management practices differed considerably within parks and to some degree within cemeteries. Two sites, one cemetery and one park, clearly differed from the others. The cemetery had more in common with the parks and the park had been without active management for the last decades, which had allowed the shrub layer to develop to an extent unequalled by any of the other areas. Our design with four replicates of each category was insufficient to deal with these differences in some of the statistical analyses. Also, a more detailed classification of functional groups might have been better able to capture the effects of different management practices (see, e.g., Rosenfeld 2002).

In the qualitative part of the study, the differences in sense of place, LEK, and, to some degree, even institutions rest on the subjective experiences and perceptions of the respondents, and we realize that our results by no means are exhaustive. One weakness with the interview study was that respondents were chosen differently in allotment gardens, on the one hand, and cemeteries and city parks, on the other. In allotment gardens, we searched for persons knowledgeable about the local social–ecological system, and we identified them in a questionnaire. In city parks and cemeteries, we only interviewed the head managers of the areas, since they make decisions about the management of their respective areas. However, the organizational position of head managers does not always correlate with knowledge about the local social–ecological system. Differences in organization, i.e., one or several managers, also resulted in more material on allotment gardens than cemeteries or parks. We do not see this as a

problem; rather, as fact and part of the explanation to why we might see differences in management practices between the three types of green areas.

*Policy implications for managing ecosystem services in complex systems*

We argue that studies like this are important to inform managers of the indirect effect of management practices primarily aimed at targets other than maintenance of ecosystem services. Awareness of positive side effects may strengthen the institutional foundation for the practices, strengthen the sense of place, and even further increase the probability that the practices will continue over time (Cantrill and Senacha 2001). This is especially important in areas where people are not strongly dependent on local natural resources, since resource dependency has been proposed as one of the strongest drivers behind successful long-term management (see, e.g., Berkes et al. 2003). A close link between practice and planning, here most evident in allotment gardens where the managers do both, has been argued to make adjustments to environmental feedback easier since the managers may detect ecological change more rapidly and have the mandate to adapt management practices accordingly (Berkes 2004). As an example of the opposite case, the management of city parks seem to be less flexible, where bureaucratic procedures must be undertaken before the direction of management can be changed. Allotment gardens, with their numerous managers, offer more opportunities for experimentation and transmission of information, and thus greater potential for more comprehensive knowledge-building than do areas cared for by a sole manager. Many managers make it easier to maintain continuity in the knowledge within the area than if the knowledge is tied to one specific manager and risk being lost if that person leaves. However, our results also indicate that sense of place is restricted to the allotment gardens and the immediate area around them, which implies that they hold a “not in my backyard” mentality (Norton and Hannon 1997).

In our study, only a few interviewees referred to the relationship between different scales (Respondents 1 and 10), but practices performed locally have landscape effects, as bumble bees and birds move outside and between areas, thus extending their services (e.g., Jules and Shahani 2003, Kremen et al. 2004, Bodin et al. 2006). The landscape perspective is, instead, held by the planning authorities. Transfer of knowledge between groups of managers could be helped by creating or making room for an organization bridging, or intermediating the divide (Cash and Moser 2000, Moss and Wissen 2005), with the aim to spark participative learning (Pretty 1995). We argue that the involvement of other stakeholders in the management of cemeteries and especially city parks would promote the same positive features that we found in allotment gardens, i.e., a strong sense of place, ecological knowledge, and

continuous learning. Not only would this improve management by getting more motivated managers, it would also increase the different stakeholders' understanding of the ecosystems that provide them with desired services.

Different management objectives create heterogeneity, which is generally held to provide an insurance against uncertainty (e.g., Folke et al. 1996, Loreau et al. 2003). Our data lends at least partial support for the importance of heterogeneity as the species assemblages of insectivores differed between cemeteries and allotment gardens and thus complement each other. Differences in species assemblages may also make the service more stable over time as different species are likely to respond differently to disturbances or changes (Elmqvist et al. 2003).

#### CONCLUSIONS

The findings in this paper show that relevant knowledge and ecosystem management exist both inside and outside the formal planning, and that different goals, constraints, and motivations create social-ecological systems that differ in their capacity to deliver ecosystem services. We ascribe the differences in management practices to social attributes such as local ecological knowledge, sense of place, and institutions. Data also support the hypothesis that local ecological knowledge correlates positively with sense of place, and our results also show the same pattern for strength and diversity of protective norms and sense of place. All three features are strongest among the informal managers and weakest among employed personnel. Formal managers have less freedom in their decisions, and a larger part of the management objectives are set centrally and change is slow moving. Furthermore, allotment gardens are different from the others in that they have many different managers within each area, something that increases the potential for experimentation and learning.

We believe that communicating the results from studies such as this could help this cooperation by highlighting, for planners and local managers both, the direct and indirect effects of different green-area management. Maintaining different types of green areas contribute to the creation of heterogeneity on a landscape level, which is generally held to increase biodiversity. A move toward participative co-management in cemeteries and, especially, city parks would hopefully promote the same positive features that we found in allotment gardens, i.e., a strong sense of place, ecological knowledge, and continuous learning.

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#### APPENDIX A

Two tables with the bird and bumble bee species found, including functional groups for birds (*Ecological Archives* A017-048-A1).

#### APPENDIX B

A list of interview and survey sources (*Ecological Archives* A017-048-A2).

#### APPENDIX C

The guide for open-ended interviews (*Ecological Archives* A017-048-A3).



# **Social-ecological memory for management of ecosystem services**

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## **Abstract**

Many ecosystem services are in decline. Local ecological knowledge and associated practice are essential to sustain and enhance ecosystem services on the ground. Here, we focus on social or collective memory in relation to management practice that sustains ecosystem services, and investigate where and how knowledge and experience about how to manage local ecosystems is retained and transmitted. We analyze such *social-ecological memory* of allotment gardens in the Stockholm urban area, Sweden. Allotment gardening supports ecosystem services like pollination, seed dispersal and pest regulation in the broader urban landscape. Surveys and interviews were performed over a four-year period with several hundreds of gardeners. We found that the allotment gardens function as communities-of-practice, where participation and reification interact and social-ecological memory is an emergent structure that persists by being both perturbable and resilient. Social-ecological memory in the urban gardening is retained and transmitted through participation in imitation practices, learning processes, oral communication and collective gatherings. It also resides in structures of chalets and garden plots and other physical forms and artifacts as well as a number of rules-in-use (institutions) of allotment gardening. Finally, a wider social context provides external support through various forms of media, markets, social networks, collaborative organizations, and legal structures. We discuss the potential role of social-ecological memory in sustaining ecosystem services in times of crisis and change and conclude that stewards of green urban areas and the social-memory that they carry may help counteract further decline of critical ecosystem services.

**Key words:** Ecosystem service, social-ecological memory, resilience, ecosystem management, Allotment gardens

## 1. Introduction

The Millennium Ecosystem Assessment concluded that many ecosystem services are degrading (MA 2005, Carpenter and Folke 2006), reflected, for example, in the world wide crisis in the pollinator service for agriculture and biodiversity (Buchmann and Nabhan 1996, Steffan-Dewenter et al. 2005, Klein et al. 2007). How can we sustain and enhance the capacity of social-ecological systems to improve the management of essential ecosystem services, like pollination of crops and other plants? In urban areas, gardening form part of the urban landscape mosaic and seem to play a significant role in pollination (Kearns et al. 1998; Biesmeijer et al. 2006), as well as for other ecosystem services that spill over to the rest of the landscape, such as seed dispersal and pest regulation (Andersson et al. 2007). In this sense, urban gardening constitutes a source of resilience for ecosystem services in the broader landscape (Colding et al. 2006). The services are the result of a cultural landscape shaped by a diversity of management practice, some explicit, some tacit (Berkes and Folke 1998). How are such practices, and the memory for their regeneration and revival, sustained and where is the memory stored?

Memory above the individual level that captures experience of societies and groups about their living pasts is often referred to as *social memory* (McIntosh 2000; Climo and Catell 2002), or *collective memory* (Halbwachs 1926 [1950]; Middleton and Edwards 1990; Coser 1992; Gongaware 2003; Rothstein 2005). According to Wenger (1998) reification is a source of remembering by producing forms that persist such as physical objects. Participation is a source of collective remembering and also through building of identities. Over time their combination in “*community of practice*” (Wenger 1998) becomes invested in a shared history (McKenna et al. 2008), and in tools, artifacts and concepts, which tend to outlive the repertoires of practices that first shaped them. Because the world is in constant flux and conditions always change, any practice must be revived and reinvented, even as it remains ‘the same practice’. The social or collective memory available to constitute a practice is thus an emergent structure that persists by being both perturbable and resilient (Wenger 1998, Folke et al. 2003). In this paper we focus on social or collective memory in relation to practices that generate ecosystem services. We use allotment gardens in the Stockholm urban area, Sweden as a case study. Here, *social-ecological memory* (SE-memory) is the means by which knowledge, experience and practice about how to manage a local ecosystem and its services is retained and stored among a group people, and modified and transmitted through time. It involves a continuous learning process (Armitage et al. 2008). We believe that SE-memory is a critical subset of any social-ecological system, providing sources of resilience to deal with change (Folke et al. 2003). It exists as part of institutions like property right regimes or community-based resource management systems (Hanna et al. 1996, Berkes and Folke 1998) and provides an important bridge between the broader social context, management practice and the generation of local ecological knowledge (Olsson and Folke 2001) in relation to ecosystem services.

There are few studies that focus on SE-memory in relation to ecosystem management (but see e.g. McIntosh et al. 2000), and considerably less related to household gardening. A prominent exception is the studies on social memory conducted by Crumley (1994; 2000) on the vernacular (vegetable) gardens in the Burgundy region of France.

There are implicit studies on social-ecological memory, which have evolved among resource users that experience regularly occurring large-scale disturbance, e.g. floods, droughts, and hurricanes (e.g. Niamir-Fuller 1998; Colding et al. 2003; Tengö and Hammer 2003). Similarly, there are studies on local communities with experience of past overutilization of their resource base, and that have developed social-ecological memory to help revive practices to avoid overharvesting of resources (e.g. Berkes 1999, Johannes 2002). Elders with extensive ecological knowledge and other similar stewards of habitats are carriers of social-ecological memory of resource and ecosystem dynamics, with observations that often include understanding of long-term and large-scale changes and ceremonies and rituals in both traditional and contemporary society play a role in activating social-ecological memory into practical ecosystem management (Lansing 1991, Berkes and Folke 2002).

The primary objective of this article is to explore social-ecological memory in relation to how and where knowledge and practice linked to ecosystem services are socially retained and temporarily transmitted, using contemporary allotment gardens as an example. The findings draw on a four-year fieldwork inventory in allotment gardens in Stockholm urban areas and a literature synthesis of the concept of social memory. Allotment gardens can broadly be described as representing ‘legacies’ of traditional household gardening practices where the users’ knowledge of gardening has been passed on and socially retained for considerable time, often over several generations. Hence, in this sense allotment gardens represent social arenas for present-day household gardening in urban landscapes. We have previously investigated the link between ecosystem services and management practices of allotment gardens (Andersson et al. 2007), where evaluation of local ecological knowledge and practices was made by analyzing the respondent’s answers to questions regarding site specific abiotic conditions, interplay between organisms and the abiotic conditions, and the behavioral characteristics of organisms, including migration, foraging, nesting, and mating. The knowledge revealed by the respondents was compared with the knowledge that the scientific community holds regarding ecosystem dynamics. Here, the focus is on social-ecological memory that carries such management practices through time and between people.

The article is organized as follows: The next part begins by providing some general background on the concept of social memory from different scientific fields and perspectives. Here we also provide a background on urban allotment gardening with a focus on Stockholm, Sweden. Part 3 describes the methods used for the four years of fieldwork on allotment gardening and the categories we have chosen to analyze SE-memory. Part 4 presents the results of the fieldwork, where we portray both internal and external features of SE-memory. Part 5 begins with a discussion of the fieldwork results and the role of SE-memory for management of ecosystem services such as pollination and pest regulation followed by a discussion on the role of SE-memory for preparing for, and responding to systemic disturbance. We end this article by synthesizing the major insights generated in this paper in the hope it will stimulate further inquiry into the role of SE-memory for reliable management of ecosystem services.

## **2. Background**

### **2.1 Social memory and human behavior**

The line of thoughts on social memory was originally developed by Halbwachs (1926 [1950]). He was a disciple of Durkheim whose work around the end of 1890s included concepts about “collective excitement” as the fertile ground for cultural creativity (Coser 1992). Halbwachs’ work showed how these lessons were kept alive through transmission between creative periods (Coser 1992). Halbwachs argued that even though it is only individuals that remember, individual memory processes derive from social interaction, and is facilitated through supra individual means shared with others, such as language, symbols, events, and cultural contexts (Misztal 2003). Accordingly, social groups construct their own images of the world through agreed upon versions of the past - versions constructed through negotiation, not private remembrance. It is in this sense that there exists a *collective memory* (Coser 1992), and it is the verbal conventions that constitute the most stable social framework for it (Halbwachs (1926 [1950]; Middleton and Edwards 1991; Misztal 2003). Anthropologists, archeologists, ecologists and other scholars, often use the concept of *social memory* (Mcintosh 2000; Climo and Cartell 2002; Folke et al. 2003), or *cultural memory* (Nazarea 1998; Misztal 2003). Here, we choose to use the term *social-ecological memory* (SE-memory) since we explicitly address memory in relation to management practices of ecosystems and their services.

The social memory of communities constitutes the variety of forms through which behaviors of people are shaped by the past, and it functions as collectively shared mental maps for dealing with a complex world (Olick and Robbins 1998; Crumley 2002; Misztal 2003; Gongaware 2003; Rothstein 2005; North 2005). Many scholars argue that memories not always represent documentaries of events, but rather constitute interpretations used in narrative constructions, tightly connected to emotions (Misztal 2003). Memories of everyday experience are therefore frequently distorted. However, traumatic memories, or so called ‘light bulb’ memories, such as of environmental crises are likely to preserve details (Schater 1995; Misztal 2003). In general the ingredients of social memory are neither a purely social construction, nor historical facts established once and for all, but rather along the line between those two poles (Rothstein 2005).

### **2.2 Allotment gardening**

Stockholm in the end of the 1800s, like many cities of Europe, faced social problems such as mass migration from the country side, overcrowding, unhealthy living conditions, and a loss of identity and values of rural living (Lindhagen 1916; Lignell 1995; Lundevall 1997; Nilsson 2000). These conditions motivated the social movement of allotment gardening to improve conditions of the landless working class (Nolin 2003). Various governmental bodies early on promoted and supported the growth and development of allotment areas. Currently Europe holds some 3 million allotment gardens, whereof 10,000 individual plots are found in the city of Stockholm, occupying 210 ha of land and involving about 24,000 people (Björkman 2000, Moberg 2003, Nolin 2003). Allotment areas are reserved for horticulture, containing tiny pieces of garden plots with individual or family management rights to land. The land is usually owned by a local municipality and located in urban or semi-urban areas (Colding et al. 2006; Andersson et al. 2007).

In Stockholm these are often considerably old (sometimes over one-hundred years), and they appear as lush green, well-managed flower rich areas which differ in size (3450 m<sup>2</sup>-70,000 m<sup>2</sup>) and spatial organization, from proper cultivation plots to more gardenlike plots with small houses and lawns. Management practices performed in these arenas support a diversity and abundance of wild bees and many other pollinators, and the heterogeneity that the gardens have on the urban landscape also increases the overall diversity of insectivorous birds (see Table 1).

Table 1. Management practices, which support insect pest regulation and pollination, were identified to be in use in 4 allotment associations in Stockholm (Andersson et al. 2007). The parenthesis shows how many percent of the total sum of the gardeners that perform the respective practice (Survey A-D).

Management practice
Composting (68%)
Winter feeding of birds (28%)
Tending nests (natural and built) for small birds (27%)
Exclusion of pesticides and synthetic manure (93%)
Tending of nests and food supply for pollinators (45%)
Tending traditional plant species (91%)

### 3. Methodology

The methodology consisted of 1) a pilot field study for learning about the phenomena of allotment gardening and for choosing areas for deeper studies, 2) a survey for identifying key respondents for interviews and also for sampling quantitative data about management practices, 3) deep interviews with key respondents and analysis of the deep interviews with guidance from literature about social memory (e.g. Halbwachs 1926[1950]; Gunn 1994; Olick and Robbins 1998; Wenger 1998; McIntsoch et al. 2000; Misztal 2003; Rothstein 2005). At this point some patterns about SE-memory emerged, which were used in, 4) a second survey with the objective to deepen understanding of how management practices are retained and transmitted, followed by triangulation through deep interviews in one of the allotment areas and analyses of document<sup>1</sup>.

#### 3.1 Pilot study and choice of field study sites

We started with a pilot study (Patton 2002) of 8 allotment gardens during spring 2003. The purpose was to gather primary information about the phenomenon of allotment gardening. We studied maps and scanned the literature and media about allotment gardening, and we observed management practices during field trips. We also engaged in informal talks and interviews with individual allotment holders. We encountered social features of allotment gardening, and how these were retained and transferred within the movement. During this phase, eleven pilot interviews were conducted with allotment holders. The respondents were selected by random sampling, and notes were taken during most of the interviews and some were audio-taped.

<sup>1</sup> Interview and survey questions available from the author S. Barthel on request: Stephan @ecology.su.se

Four allotment areas were chosen for this study of social-ecological memory. These were located in Stockholm City, which is the most densely populated area of Sweden with a population of 1.8 million (SCB 2005). One allotment area is located in the city center (*Barnängen*), another is located just outside the city (*Söderbrunn*) and two are located in suburbs in the proximity of the city (*Kvarnvreten* and *Stora Mossen*). These areas were chosen after three criteria: age (older than 50 years), physical structure (garden plots with chalets), and location (radius within 10 km from the city center).

### **3.2 First survey**

The second step was a questionnaire, which was sent out to all gardeners in the four allotment associations, 534 persons in total (Survey A-D, see references). The questionnaire contained 20 questions and the survey was conducted during spring 2004 and spring 2005. Responses were anonymous. The objective with the survey was to get information about management practices and local customs related to gardening, and to identify key informants for the interview study. A key informant was defined as an allotment gardener who had been named by his/her gardening neighbors as especially knowledgeable about gardening and the local ecosystem (Davis and Wagner 2003). The purpose with identifying key informants for semi-structured interviews was to extract maximum information about SE-memory in relation to gardening from a minimum of respondents (Patton 2002). More than two thirds (68%) of the allotment holders responded to the questionnaires.

### **3.3 Open-ended interviews**

Twenty five semi-structured interviews were carried out (see references). Drawing on grounded theory (Patton 2002), sixteen of the interviews were conducted at garden plots of the identified key informants. They took place during spring and summers of 2004 and 2005. The purpose of the interviews was to 1) identify practices and means of communication for the generation, revival and transmission of management practices in relation to ecosystem services within the gardening community and between generations and 2) identify where social-ecological memory that enables management practices is retained and stored, both within the community and externally. Written-down questions were used as a guideline when conversations did not flow. These questions were open ended (Kvale 1997) with the possibility to follow up clues that appeared during the interviews. The dialogues revolved around the following points i) management practices and ecological knowledge, tacit as well as explicit, in relation to ecosystem services ii) retention, modification and transmission of management practices. The interviews ended with walks around the gardens together with the respondents, which gave opportunity to talk about the various objects there. All interviews were recorded and transcribed and the length of the interviews varied between 60 and 90 minutes. The transcribed interviews were analyzed by classifying answers of the respondents related to gardening in the categories of Table 2 below. One further interview was conducted with the head of the Swedish allotment union for attaining information about organizational structure and history of the movement. Another five interviews were conducted with people outside the allotment movement, including public park managers and the head city gardener of Stockholm to understand perceptions held by management authorities about allotment gardening and its ecological function in the urban landscape.

### 3.3.1 Data analyses

In order to classify features of social-ecological memory in the transcribed interviews we iteratively used theory developed within the fields of collective memory and social memory (e.g. Halbwachs 1926[1950]; Gunn 1994; Olick and Robbins 1998; Wenger 1998; McIntsoch et al. 2000; Misztal 2003; Rothstein 2005). According to Halbwachs (1926 [1950]) collective memory can be divided in two major frameworks 1) autobiographical memory, which is about narratives of identity based on individual experiences and 2) historical memory which includes information stored in institutions, physical forms and written accord. Halbwachs work shows similarities with ideas of how social practice evolves in communities, where according to Wenger (1998) practice emanates from the interplay of *participation* (a process of taking part or share with others) and *reification* (making an abstraction into an object that endures). It is first and foremost, a dual process by which we can experience the world and our engagement in it as meaningful (Wenger 1998). With time shared histories are being built up in *Mnemonic* communities of practice (Wertsch 2002; Misztal 2003).

Acquisition and transmission of memory is facilitated through personal experiences of participation (Wenger 1998). Oral communication is stressed as central for reproducing collective memory and meaning according to almost all of the analyzed literature (e.g. Halbwachs 1926[1950]; Middleton and Edwards 1991; Stein 1995; Olick and Robbins 1998; Wenger 1998; Wertsch 2002; Misztal 2003). The fact that memories are often organized around landscapes, suggests that remembering occurs in the physical Earth and is something that involves our senses (Misztal 2003), which is why participation modifies social memory in a constantly changing environment (Gunn 1994; Scott 1998). Some social practices are habits, such as established collective practices that are regularly repeated (Wenger 1998; Misztal 2003). Through habits social memory is passed on, often tacitly, in embodied, non-textual and non-cognitive ways (Misztal 2003; Nazarea 2006). This phenomenon is sometimes referred to as *habit memory*, and it is reflected in bodily postures, activities, techniques and gestures, and through practice it brings the past into the present. This is in line with Crumley's (2002) and Nazarea's (2005) findings, which suggest that non-verbal forms, such as gardening practices, transfer ecological information temporally.

Retention and transmission of social memory is facilitated through reification processes (Wenger 1998), which both constrain and enable participation as reification provides social cues for interpersonal relations (Hollis 1994) and for relations to ecosystems (Berkes and Folke 1998; Nazarea 2006). Reification includes objects, phrases, metaphors (Wenger 1998) and institutions or *rules-in use*, including regulations, informal norms and property rights (Ostrom 1990; North 1994). Artifacts such as tools, written material, pictures and media are other aspects of reification. Reification also includes places, ruins, landscapes, monuments, and architecture-which all are important for retaining social memory (Halbwachs 1926 [1950]; Wenger 1998; Misztal 2003).

We used the notions of participation and reification as a classification scheme when developing four classes of internal social-ecological memory of allotment gardening, where the first two represent participation and the following two represent reification.



Literature also stresses the significance of external reserves of memory for internal social memory (Folke et al. 2003; Nazarea 2006). Not surprisingly, the empirical data revealed that sources external to allotment gardening retain and transfer social-ecological memory, which is why a fifth class was developed (Table 2).

Table 2. Categories of social-ecological memory in the allotment gardening and the criteria for choosing them

<b>Category</b>	<b>Criteria</b>
Collective/individual habits and practices	Imitation of practices, repeated gatherings, learning by doing
Oral communications	Dialogues, discussions, sharing of experience, learning, teaching
Rules-in-use	Norms, regulations and property rights
Physical forms/artifacts	Written material, pictures, places, tools
External sources of support	Features of participation and reification external to individual allotment gardens

The next step in our data gathering was to get quantitative triangulation on the credibility of these five classes of social memory. This is why we conducted a second survey.

### **3.4 Second survey and final interviews**

Based on the patterns that emerged about what constitutes social-ecological memory, we conducted the second survey (Survey E, see references) on one of the original four allotment gardens. It was conducted during spring 2007. A questionnaire was sent out to all gardeners' in *Söderbrunn*, which is the oldest one in Stockholm (established 1904), which also contains a high number of garden plots (190), and which also had the highest response frequency during the first questionnaire (82%). Further, *Söderbrunn* has also recently been under threat of exploitation, but has successfully responded to this disturbance (see section 5.2). The 23 questions all revolved around the five classes of social-ecological memory presented in Table 2. Respondents were anonymous. The objective with the survey was to deepen understanding of how practices are retained and transmitted. The second questionnaire received a response frequency of 56%. Patterns that emerged from the second survey were triangulated by three follow-up interviews and further text analyses of documents. At this point saturation of information was achieved.

## **4. Social-ecological memory in relation to allotment gardening**

Social-ecological memory in the investigated allotment gardens in urban Stockholm is retained and transmitted through participation in mimicking or imitation practices, learning processes, oral communication and collective gatherings (Wenger 1998). It also resides in reification processes, creating points of focus around which gardeners organize negotiation of meaning. This includes structure of garden plots, of chalets and other physical forms and artifacts such as booklets, as well as a number of rules-in-use (institutions) in allotment gardening. Finally, a wider social context provides external memory support through e.g. magazines, books, internet, tv, garden markets, various social networks, unions and legal frameworks (Table 3).

Table 3. Social-ecological memory identified in the study than retain and transmit knowledge and experience for managing ecosystem services in allotment gardening.

<u>Participation</u>		<u>Reification</u>		<u>External sources</u>
<b>Collective/individual habits and practices</b>	<b>Oral communications</b>	<b>Rules-in-use</b>	<b>Physical forms/artifacts</b>	<b>Artifacts, laws, social networks</b>
Spring/fall management of the commons	Conversations with relatives	Property rights	Architecture of chalets	Magazine "Kolonisten"
Childhood experiences of imitating adults	Daily small talk in the gardens	Norms of justice and democracy	Form of garden plots	Other garden magazines
Parties	coffee breaks	Choice of traditional flowers	Form of commons	Garden-books
Trial-and-error gardening	Negotiations	norms for planting vegetables	Booklets	Internet
Mimicking practices of neighbors	Dialogues	Protection of species	composts	TV-shows
exchange of seeds and plants	Listening to people with experience	Exclusion of pesticides	Nesting-boxes, bird-baths, bee-hives, etc.	Organizing into unions
			Plants and trees	
Funeral-rituals	Board meetings (internal)	Organic soil fertilization	Documented meetings	Social [ego] networks
	Active teaching of less experienced neighbors	Internal rules of conduct	Instruments/tools	Legal frameworks
			Phrases and sayings	Garden trade fairs
			Booklets	Garden courses
			Sense of place	Board-board meetings (external)

#### 4.1 Participation

Participation involves acquisition, transmission and modification of SE-memory. It refers to a process of taking part and sharing and also to the relations with others that reflect this process. Hence, it suggests both action and connection and mutual recognition. It goes beyond collaboration and involves all sorts of relations, including conflicts. Participation shapes our experience of meaning, and it also shapes communities (Wenger 1998).

In concordance with the literature on social memory (see methods section) both interviews and questionnaires revealed that oral communications are the most important means of transmission of ecological practices and knowledge in allotment gardening.

Since there are no physical barriers between garden plots, conversations flow spontaneously. The first survey revealed that 57% learn about management practices during daily talks with other gardeners within the allotment garden, and 18% learn about gardening primarily by talking with external experts (Survey A-D, see references). Newcomers tap into the community of practice primal through conversations with experienced neighbors, and through programs of teaching by appointed mentors. Among allotment gardeners, 57% think that learning from older and more experienced gardeners is the most important mean for transmission of knowledge and memory, and 66% of them teach less experienced gardeners about practices (Survey E).

“I talk to older gardeners, especially my 85 year old neighbor, who has the longest experience from growing plants here”  
(Respondent 3)

Participation also includes sharing of seeds, plants and recipes, and 56% of the respondents share seeds with their neighbors (Survey E).

“We acquire many of the plant species through exchange with each other”  
(Respondent 8)

Imitation of practices is another important habit for transmission of practices related to gardening. Results of the second survey (E) reveal that 86% of the respondents have personal childhood memories of watching adults as they were tending gardens.

“I learned it during the 50s. There was no one special that thought me. I just came a long and imitated what others where doing, and sometimes I just asked”  
(Respondent 15)

Imitations of practices continue as people develop into knowledgeable allotment gardeners. People are observing and mimicking each other as a way of developing new skills (Respondents 1-16).

“One of my neighbors had an enormous amount of lice on a plant and he went around the garden to collect ladybirds which he placed on the plant. The ladybirds started to feed on the lice at once”  
(Respondent 4)

As participation in allotment gardens include inter-relational processes not only between people, but also between people and ecosystems, individual trial-and error practices generate experiences and modify SE-memory. Gardeners monitor how local ecological processes, plants and various organisms respond to their management practices (Respondents 1-16). Monitoring ecosystem change constantly reassesses and revives management practices, even as they remain ‘the same practice’.

“I learn about how the garden changes by daily trial-and error practices”  
(Respondent 3)

“It is not possible to grow potatoes on the same plot every year. You have to shift every 3-4 years to avoid soil-fungus. To re-generate the soil I shift with peas of different varieties.”  
(Respondent 5)

Participation is also reflected in self-organized collective meetings, parties and other repeated social gatherings (see Table 3). Democratically elected boards of allotment gardens hold ongoing meetings during the year. They negotiate about how to run the association, such as how to handle rule breakers, or how to distribute labor of the commons, about water issues and how to deal with landholders. There are yearly compulsory collective rituals for all gardeners. Included is the compulsory spring/fall management of the commons (Respondents 1-16; Survey E).

## 4.2 Reification

Participation organizes itself around *reification* because it always involves artifacts, phrases, and concepts that allow it to proceed (Wenger 1998). Reification is abstractions, emotions or metaphors conceived as *things* and functions as shortcuts to communication. It carries memory beyond participation, for instance through phrases or concepts used among allotment gardeners to recollect local ecological dynamics (Respondents 1-20).

“I wait to plant the one-year’s till’ after *The Iron Nights*”<sup>2</sup>  
(Respondent 11)

In allotment gardens reification processes load the place with shared histories of ongoing learning and negotiation about meaning, and results with time in an emotional attraction, referred to here as sense of place. Continued labor and participation deepens the sense of place further (Norton and Hannon 1996; Andersson et al. 2007). Sense of place is often expressed as emotions and coherence linked to the allotment garden (Interviews 1-16).

“This place is like an oasis for my soul”  
(Respondent 13)

Artifacts, such as documented board meetings and booklets with photographs are other examples of reification in allotment gardens. Moreover, physical forms such as cottages, hedges, nesting-boxes, vegetable plots, fruit trees as well as flowers are all central for retaining memory (Table 3).

“The value of putting up nesting-boxes is that the small-birds, mainly Great tits and Blue tits, feed on the insects in the apple-trees.”  
(Respondent 7)

The second survey (E) revealed that 40% of the respondents have plants in their garden that originate from deceased family members or friends.

“These wild strawberries are from the garden of my father. It is wonderful to have something like that to remind me of him”  
(Respondent 8)

Rules-in-use or institutions (Ostrom 1990; North 1994; Colding and Folke 2001) are points of focus around which gardeners can organize negotiation of meaning. The spatial size and form of cottages and gardens are determined by strict rules, which may be experienced as authoritarian.

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<sup>2</sup> ‘*The Iron nights*’ according to Swedish folklore, is nights in the beginning and the end of the summer, which is particularly exposed to night frost. According to sayings, they occur at different dates in different parts of the country (Nordisk familjebok 1910).

“About the gardening rules, it is the board of this association that sets them. Once a year the board surveys all garden plots and if rules have been broken the garden holder may ultimately be thrown out”  
(Respondent 7).

The rules-in-use provides structure and framework for participation, including norms for cooperation and decision-making. The gardeners themselves decide on how to organize management of allotment gardens, and allotment associations commonly enforce their own rules. Individual allotment holders are organized in associations, with elected chairmen and committees, and the individual plot holders share obligations and regulations for the management of the whole area, but manage their own plot relatively independently. Members have equally sized plots, and there are norms of equity when transferring property rights. The market does not set the prices of garden plots. Instead, these are priced by educated and appointed members<sup>3</sup> of the Allotment union<sup>4</sup>, which evaluate chalets and gardens based on the work and material that has been put into these units of property.

There are norms that guide behavior towards the ecosystem. For example, norms to exclude pesticides and synthetic manure are strong, and 93% of the gardeners follow this ethic (Survey A-D). Plants can be chosen freely, with exceptions of few plants that are prohibited by law. However, there are norms that urge garden holders to grow vegetables, fruits, berries and traditional flowers (e.g. Respondents 6, 9, 12, and 13).

These norms are evident since 91% of the gardeners *feel* that their neighbors want them to act in accordance with these norms (Survey A-D).

“One third of the garden should be used to grow vegetables...you can not use pesticides that could harm bees, bumblebees or other pollinators”  
(Respondent 9)

Examples of rules-in-use include distinct norms about environmental ethics and protection of pollinator species and small birds (Respondents 1-16).

#### ***4.3 External sources of social-ecological memory of allotment gardening***

We have also identified sources of SE-memory (Table 3) related to gardening that we choose to characterize as ‘external sources of support’, since they exist outside the practices of individual allotment gardens.

The Swedish allotment union<sup>5</sup> ([www.koloni.org](http://www.koloni.org)), and its regional compartment, the allotment union of Stockholm<sup>6</sup> ([www.fssk.se](http://www.fssk.se)) are considered the most important external organization for retaining and transmitting the tradition of allotment gardening, by a majority of the respondents (Survey E). Most allotment associations are members (Respondent 17) and the unions provide garden courses, print and distribute a magazine on gardening, and facilitate relations with authorities.

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<sup>3</sup> [Swe. Vårderingsmän]

<sup>4</sup> [Swe. Föreningen Storstockholms Koloniträdgårdar]

<sup>5</sup> [Swe. Svenska förbundet för koloniträdgårdar och fritidsbyar]

<sup>6</sup> [swe. Föreningen Storstockholms koloniträdgårdar]

Other examples include that board members are directly engaged with boards of other allotment gardens (Table 3), with which they attend regular meetings on a yearly basis (Respondent 6; Survey E). Individual gardeners seem to be prepared to use contacts in their personal networks in politics and media for creating support and public acceptance for allotment gardening (Survey E).

Written accord and media is an identified reification related to participation with the allotment union (Table 3). Written accord and media transmit, retain and modify local SE-memory. The first survey (A-D) revealed that 54% use written accord when solving problems in relation to gardening. There is a magazine that allotment gardeners receive five times a year called “The allotment garden”<sup>7</sup>, published by the Swedish allotment union. It is prioritized by 77% of the gardeners when reading about horticulture.

”I read *’The allotment garden’* and many books about horticulture”  
(Respondent 9)

This magazine has a circulation of 30,000 and is about garden practices, about environmental issues and related science, and about what is going on in this social movement (www. koloni.org). Gardeners also read other garden- and horticulture-related magazines and books (respondents 1-16, survey E).

Another type of external reification is legal means (Table 3). In Stockholm, the legal framework that allows allotment gardening is leaseholds from municipalities. Land used for allotment gardening represent *proprietorship* (Table 4), a property right where management rights to land and/or natural resource(s) are in the hands of an identifiable community or group of users that may craft their own *rules-in-use* for management of land within given legislations (Ostrom and Schlager 1996). Allotment areas may also be embedded in other protective laws, as two allotment gardens in our study area are located within the borders of a park of national interest (Barthel et al. 2005).

The other two of this study are outside the borders of this park and exposed to other influences. Some allotment areas in Stockholm also receive protection in law because they are contained within the borders of nature reserves (Colding et al. 2006).

Table 4. Bundles of property rights associated with positions (Schlager and Ostrom 1992:252). The five property rights in the table are independent of one another, but are frequently held in the cumulative manner arranged as shown. They include the rights of *access*, *withdrawal*, *management* (the right to transform the resource by making improvements); *exclusion* (the right to determine who will have an access right, and how that right may be transferred); and *alienation* (the right to sell or lease)

Rights	Owner	Proprietor	Claimant	Authorized user	Authorized entrant
Access	X	X	X	X	X
Withdrawal	X	X	X	X	
Management	X	X	X		
Exclusion	X	X			
Alienation	X				

<sup>7</sup> [swe. Koloniträdgården]

## 5. Discussion

The results reflect that social-ecological memory related to allotment gardening in the Stockholm urban area is an emergent process that emanates from communities-of-practice. SE-memory is retained and transmitted through participation processes, in physical forms and artifacts, by rules-in-use that structure and frame the gardening and through a diversity of external support processes (Table 3).

### 5.1 The dynamics of SE-memory in allotment gardens

Allotment gardens hold most of the characteristics described for communities of practice (Wenger 1998), such as mutual engagement, shared jargon, enterprise and repertoire, which includes routines, words, tools and stories by which members create meaningful statements about the world. They constitute social arenas for local ongoing processes of learning and negotiation, which continually create shared histories. Participation is a source of collective remembering and also of building identities. It is about engagement not only with people, but also with place and ecosystems, which generate depth and horizons of lived experience, emotionally reified as sense of place (Norton and Hannon 1997). Reification is a source of remembering by producing forms that persist such as, attachment to place, cottages and booklets (Wenger 1998).

Participation transfer SE-memory partly by oral communication, which corresponds to findings about community-based conservation where convincing points are made about the role that oral communication plays for transferring ecologically sound practices (Berkes 1999; Berkes and Turner 2006; Pilgrim et al. 2007).

In allotment gardens, the current physical forms are products of past participation. This includes sizes and forms of the individual gardens, fruit trees, hedges, the commons, and it influences present engagement and relations. For instance, the open character of the allotment gardens, with few hedges or fences enables gardeners to engage in spontaneous daily conversations and mimicking management practices. In this way the physical form facilitates participation that transmits SE-memory. The gardeners tend to hold on to the spatial form of the place since it gives them opportunities to engage and bond (Respondents 1-16). Moreover, this spatial form also directly influences ecological processes, such as pollination, since it is also about what you grow, how you do it, and how you are allowed to do it. For instance gardeners often tender plants that attract pollinators (Survey A-D), which increase the quality of the habitat for pollinating insects (Andersson et al. 2007).

Reification and participation function as distinct but interrelated modes, as a dual process, which with time generate SE-memory. SE-memory allows gardeners to proceed without needing to know everything, and helps newcomers to join the community by participating in its practices (Wenger 1998, Stein 1996; Berkes and Folke 2002; Nazarea 2006). Over time allotment gardeners become part of a shared history, with rituals and symbols that tend to outlive the repertoires of practices that first shaped them (Wenger 1998).

In allotments there are both norms concerning social conduct, as well as norms concerning practices towards the ecosystem. The norms of social conduct seem to originate from the establishment of the social movement of allotment gardening, while the norms concerning engagement with the ecosystem seem to originate from the millennia old culture of keeping a kitchen garden in traditional European farming systems (Crumley 1994; 2000) refined during centuries of allotment gardening (Respondents 8, 14 and 15, Lindhagen 1916). An example of norms concerning engagement with ecosystems is protection of wild bees. On all allotment areas in this study, gardeners grow flowers with the only intent to feed pollinators and many improve habitats for nesting (Table 1). Unknown by management authorities in Stockholm (Respondents 21-25), these practices support the abundance of wild bees and the ecosystem service of pollination (Andersson et al. 2007), not only within individual gardens, but over much larger areas of the urban landscape (Osborne et al. 2001; Greenleaf et al. 2007). Enhanced pollination feeds back to the gardeners, since pollination underlies the generative capacity of flowers, fruits and many vegetables, which are of prime concern for gardeners. Participation reproduces this norm, via mimicking and oral means, and strengthens it (Knight 1997; Mahoney 2000).

Although SE-memory may be rather resilient, it is simultaneously constantly metamorphosed (Nazarea 2006), not only because we forget and remember partially, but also because our forms of participation change, our perspectives change, and we experience life in new ways. New types of information are dynamically interwoven with SE-memory, and there are potentials for combining and recombining it, adding and filtering influences, as well as transferring it in time and space (Folke et al. 2003). For example, fast-acting carriers of information (e.g. media and gardening magazines, including scientific knowledge), continuously modify SE-memory.

Practitioners adjust to everyday multiple subtly differing situations and incorporate, by monitoring ecological feedbacks, many small, almost imperceptible variations that a constantly changing context creates (Scott 1998; Agrawal 2002). As a result any practice must be revived and reinvented, even as it remains 'the same practice'. The SE-memory thus is an emergent structure that persists by being both variable and resilient (Wenger 1998, Folke et al. 2003).

## 5.2 External sources of resilience of local SE-memory

Most urban landscapes today are characterized by traffic congestion, population growth and the privatization of public domains (Harvey 1996; Carley and Smith 2001; Fyfe and Kenny 2005; Webster 2006). These processes pose tremendous pressure on urban ecosystems (Collins et al. 2000. Grimm et al. 2000; Kinzig and Grove 2001; Alberti et al. 2003; May 2004), and contest for open space is intensifying, and such processes are major threats to allotment gardens in Stockholm. Therefore external sources are paramount for supporting local SE-memory.

The results illustrate that there exist both reification processes and organizational activity (participation) that support allotment gardening among citizens of Stockholm. Historically, allotment areas have mobilized to protect their integrity by union formation.



Until 1920 the allotment movement was dependent on voluntary work by small number of champions. 1921 City employees gained control over the movement and they intended to cut down the number of allotments in Stockholm with 80%, so as to free land for constructions. The response of the allotment gardeners was the formation of a nation wide network of allotment associations and politicians, which successively gained power. The organization was named the Swedish Allotment Union, and it has been aiding individual allotment associations ever since (<http://www.koloni.org/pdf/01.pdf>).

Another related aspect of external means of participation for responding to the expanding city is self-organized ego networks of individual allotment holders (Survey E, respondents 18, 19 and 20). Such personal relationships and experiences from organizations outside allotment associations constitute weak links (Granovetter 1973), or bridging links, in relation to the allotment gardens, which are important for assessing various kind of resources for communities (Bodin et al. 2006). For example, when the National Railway Company (NRC) wanted to expropriate land on one allotment garden, such weak links were proven essential. The NRC got legal permission to construct in the area despite that it was within the boarders of a park of national interest (the National Urban Park). Over 100 trees were cut down in a nearby wetland, which was partly drained and individual garden plots in the allotment area were threatened. One key individual, who also was the head of the allotment board, used her external personal contacts and experiences of media to respond to the crisis, and the tiny little allotment garden won the struggle against the National Railway Company (Respondents 18, 19 and 20). This example illustrates that even though the SE-memory of allotment garden results in synced gardening practices (table 1) there is a vast potential diversity in responding to change and challenges when dealing with external authorities due to weak links in ego networks (Survey E).

The surveys and interviews identified written material as an important external means of reification. Besides retaining and modifying SE-memory, it is reasonable to think that books and magazines, TV-shows, and articles in papers about allotment gardening provide both social support and a broadened public acceptance. Legal frameworks are among other identified external reification processes.

Allotment gardens can be regarded as urban commons (sensu Ostrom 1992; Colding, *in press*) enabled by the institution of proprietorship. This institution is one central point of focus around which negotiations are organized between the allotment movement and municipalities. In contrast to the situation for many so called 'community gardens' in the U.S. where leaseholds are on one year basis, leaseholds of allotment gardens in Stockholm are usually written on long-term basis. Renewable leaseholds up to 25 years between a local allotment association and the local municipality are common in Stockholm. These long term leaseholds enables allotment gardens to freely self-organize, and to invest in physical structures and in long lived organisms, such as fruit trees. Such long term engagement is needed for the emergence of SE-memory in communities of practice, a feature crucial for addressing ecosystem processes underlying the generation of many ecosystem services, as discussed in the coming section.

### 5.3 General aspects of SE-memory for management of ecosystem services

Social scientists emphasize the role of social memory in relation to meaning and identity of individuals and groups (Halbwachs 1926 [1950]; Misztal 2003). We see the value of this research, and stress the significance of the role of social memory in relation to management of ecosystem services, here referred to as social-ecological memory. It has been suggested that sustainable management and governance of social-ecological systems call for a complexity approach, and that the time for “blue-print management” is over (Holling and Meffe 1996; Ostrom et al. 2007). This paper suggests that time is ripe for incorporating the complexity of locally evolved SE-memory, a reflection of the coevolutionary process between people and nature (Norgaard 1994). Folke et al. (2003) proposed that experiences of disturbance, and surprise in space and time, must be stored and continuously modified in the memory of resource users and managers for dealing with social-ecological complexity. This seems critical since communities of practice may also be mal-adaptive to local and regional circumstances, if evolved in different environmental dynamics (McGovern 1994) or decoupled from local environmental dynamics (Holling and Meffe 1996). Mal-adaptive memory may lead into dire straits, since individuals have a tendency to lock into one of several interpretations of reality, and to the same behavior as peers in the same group. Historically this has led to increased rigidity and to clinging on to mal-adaptive structures and habits as a response to crises, reducing the chance for innovative change (Scheffer and Westley 2007).

A sustainable flow of desirable ecosystem services depends on the resilience of social-ecological systems (Berkes et al. 2003), referring to the capability to absorb change and surprise, utilize it, reorganize and continue to develop without tipping over critical threshold to alternative trajectories (Carpenter and Folke 2006). According to Carpenter et al. (2001) management needs to address slowly-changing ecosystem processes, because those are of significance in relation to thresholds. In this context, social-ecological memory becomes important.

Scholars have largely ignored how social memory emerges in relation to ecosystem management, and its role in addressing place specific ecological processes, particularly those that are slowly-changing. Muchagata and Brown (2000) touch upon this issue when they describe that newly arrived colonists in eastern Amazonia rapidly develop detailed knowledge about resources, but remain ignorant of ecological processes underlying these resources. Knowledge about such processes is related to the length of settlement, they argue. Ballard and Huntsinger (2006) arrive at a similar conclusion, as they detect time dependent differences in relation to knowledge about ecological processes among forest harvesters in the Pacific Northwest. People’s interpretation of how ecosystem processes respond to their practices seems dependent on the length of the retained experiences. Both these examples are in line with insights in the literature about social practice and memory (Wenger 1998; Misztal 2003) in that it takes time to develop.

Horticulture in Europe goes back maybe as far as 6000 BP (Crumley 1994). Drawing on the notion that acquisition of practices typically follows resource crises (Folke et al. 2003; Berkes and Turner 2006) in combination with the dynamic learning of communities of practice (Wenger 1998), it is reasonable to hypothesize that traces of experiences about slow changing ecosystem variables and critical thresholds are retained in SE-memory of horticulturalists, including allotment gardeners.

Our results indicated, however, that gardeners often seem ignorant of the ecological significance of their practices (Respondents 1-16). An example of such a practice is the protection of insectivorous birds (Table 1) supporting the ecosystem service of pest regulation (Franz 1961, Mols and Visser 2002, Sekercioglu et al. 2004, Ellis et al. 2005; Andersson et al. 2007). The functional link between this practice and such ecological processes is embodied tacitly in habitual practice. In so called habit memory (Misztal 2003; Nazarea 2006) this management practice is carried forward in time, supporting small birds that regulate disturbances acting on longer time scales than those perceived by most gardeners, which are a couple of decades at the most (Andersson et al. 2007). These aspects of social-ecological memory are ecologically important particularly during times of disturbance events, such as pest outbreaks. It seems like allotment gardeners engage in reducing risk and preparing for up-coming disturbances even though it lies in the subconscious, beyond the cognitive and rational. This tacit aspect of SE-memory embodied in habits and linked to social-ecological resilience demands further investigation in relation to ecosystem services. It may well be as important for management of ecosystem services as the parts of memory that managers are aware of and rationally discuss (Smith and Wishnie 2000; Berkes 2007).

## **6. Further explorations**

SE-memory in relation to ecosystem services is connected to active stewardship and management practice on the ground. SE-memory for the allotment gardeners is about identity and emotions connected to people and place, reflected in practices for actively dealing with social change and environmental dynamics (Respondents 1-16). Excluding local people and their practices will erode SE-memory linked to ecosystem services (Nabhan 1997; Negri 2005; Nazarea 2006).

Currently, urbanization erodes more ecosystem services and is more geographically ubiquitous than any other human activity (Grimm et al. 2008). Urbanization tends to lead to increased homogenization of habitats, fauna and flora (McKinney 2006) and impoverished metropolitan areas (Miller 2005). Green urban commons, such as allotment gardens, can help counteract such developments (Colding et al. 2006), facilitate social learning about ecosystem services (Theodori et al. 1998; McDaniel and Alley 2005; Pilgrim et al. 2007) and make possible the emergence of SE-memory and associated practice that support ecosystems services in urban landscapes.

They serve as learning platforms for tapping into SE-memory linked to ecosystem services such as soil processes, pollination or pest regulation (Koisor et al. 2007; Maron and Fitzimons 2007) in the same way as vernacular gardens in French Burgundy serve as living classrooms for the transmission of information about local climate, soils, and moisture regimes (Crumley 2002).

We have investigated the social-ecological memory of allotment gardens in relation to ecosystem services and illustrated that participation and reification among such communities of practice are central in its emergence, retention and transmission. SE-memory of allotment gardening contributes to sustaining ecosystem services in the broader urban context. Time is ripe for scholars interested in sustainability, to investigate the role and emergence processes of SE-memory in ecosystem management and resilience in order to help counteract further decline of critical ecosystem services.

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### Internet

- <http://www.fssk.se/> Föreningen Storstockholms koloniträdgårdar. 20080724
- [www.koloni.org](http://www.koloni.org) Svenska förbundet för koloniträdgårdar and fritidsbyar. 20080724

## Interviews

Respondents	Date	Area
1. Inger-M.	20030528	Allotment of Söderbrunn
2. Inger-M.	20040616	Allotment of Söderbrunn
3. Lars	20030528	Allotment of Söderbrunn
4. Jannike	20040701	Allotment of Söderbrunn
5. Bo	20040830	Allotment of Söderbrunn
6. Kerstin	20030918	Allotment of Barnängen
7. Åke	20040511	Allotment of Barnängen
8. Ingrid	20040511	Allotment of Barnängen
9. Sonja	20040527	Allotment of Barnängen
10. Siver	20040622	Allotment of Kvarnvreten
11. Elfride	20040622	Allotment of Kvarnvreten
12. Benkt	20040622	Allotment of Kvarnvreten
13. Ingrid	20040617	Allotment of Kvarnvreten
14. Ingemar	20050905	Allotment of Stora Mossen
15. Ingrid	20050906	Allotment of Stora Mossen
16. Christina	20051009	Allotment of Stora Mossen
17. Monicha [telephone]	20051024	Föreningen stor stockholms koloniförening FSSK
18. Inger-M.	20070604	Allotment of Söderbrunn
19. Inger-M.	20070613	Allotment of Söderbrunn
20. Lars	20070916	Allotment of Söderbrunn
21. Carina	20 050 516	City Park of Vanadislunden
22. Magnus	20050520	City Park of Humlegården
23. Peter	20050427	City Park of Enskedeparken
24. Jan	20050518	City Park of Råambshovsparken
25. Margareta	20050620	Head city gardener of Stockholm

## Surveys

Survey	Date	Place	Nb. respondents	Response freq.
<b>Survey A</b>	2004 04	Allotment of Söderbrunn	190	82%
<b>Survey B</b>	2004 04	Allotment of Barnängen	42	67%
<b>Survey C</b>	2004 04	Allotment of Kvarnvreten	110	54%
<b>Survey D</b>	200505	Allotment of Stora mossen	192	69%
<b>Survey E</b>	200703	Allotment of Söderbrunn	190	56%

# **Ecological scales and social network structure: management and governance of urban ecosystem services in Stockholm, Sweden<sup>1</sup>**

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<sup>1</sup> This is a modified version of a manuscript with the same title and the same authors published in Henrik Ernstson's doctoral dissertation (Ernstson H (2008) *In Rhizomia: Actors, Networks and Resilience in Urban Landscapes*. Doctoral Dissertation. Stockholm University, Stockholm. URL: <http://urn.kb.se/resolve?urn=urn:nbn:se:su:diva-8137>)

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**Abstract**

Continued management and protection of ecosystems in urban landscapes are crucial for the generation of ecosystem services. One central challenge to sustain the generation of urban ecosystem services is to address scale mismatches between ecological processes on the one hand, and the social processes of governance on the other. In this article we synthesize a set of case studies from Stockholm, Sweden, and discuss how actor groups engaged in ecosystem management can be linked to each other through social networks so as to match spatial scales of ecosystem processes. This paper highlights the importance of management practices of informal actor groups that take part in ecosystem management on the ground. It also identifies gaps in current green area governance, and therefore suggests an alternative network structure organized around three ecological scales; local green areas, city-green networks and the regional green infrastructure. We discuss governance of resilience with the aim of securing the flow of ecosystem services in this urban landscape. A diversity of actor groups including civil society groups and state agencies are each recognized as having roles and responsibilities on different spatial scales. For this to be realized there are needs to facilitate the emergence of actor groups that address the ignored city-green network and of scale-crossing brokers engaged in practices with the main objective to connect actors that currently ignore each other.

**Keywords** Ecosystem management · adaptive governance · scale mismatch · resilience · social network structure · ecosystem services · urban ecology

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## 1. Introduction

Urban landscapes represent an end point of a gradient of social-ecological systems in which human activities effect ecosystem processes (Collins et al. 2000; Grimm et al. 2000; Pickett et al. 2008). At the same time, urban green areas are recognized for their role in generating ecosystem services critical for human well-being and sustainable development (Daily 1997; Bolund and Hunhammar 1999; McGranahan et al. 2005; MA 2005). Services range from providing shade and space for recreation, filtering of aerosols and absorbing CO<sub>2</sub> emissions, to pollination, pest regulation and seed dispersal processes that support biodiversity and the ability to maintain ecological function (Alberti 2005; Andersson et al. 2007). Furthermore, in a rapidly urbanizing world (UN 2007), access to green areas could prove crucial in enhancing broad-based public support for environmental governance of degrading ecosystem services (Pyle 1993; Miller 2005; MA 2005). This paper addresses the urgent research area put forward by the millennium ecosystem assessment, which is governance of ecosystem services in urban landscapes (MA 2005).

Urban governance of social-ecological systems faces several challenges. Urban landscapes are characterized by heterogeneity and contested land use, by rapid social change, limited capacity for ecological renewal, and by the many administrative units (Collins et al. 2000; Pickett et al. 2001; Borgström et al. 2006; Heynen et al. 2006; Grimm et al. 2008). These characteristics have been argued to produce a tendency for scale mismatch (Borgström et al. 2006), i.e. a temporal or spatial mismatch between the scale of ecological processes and the scale of social organization of governance (Folke et al. 1998; Cumming et al. 2006; Olsson et al. 2007; Galaz et al 2008).

This paper is about how to develop a social organization of governance that supports ecosystem management. Although studies in urban ecology have analyzed cities as social-ecological systems, they have mainly been focusing on how the heterogeneity of land use patterns affect ecosystem function (Alberti 2005; Cadenasso et al. 2006; Grimm et al. 2008; Pickett et al. 2008). Many studies regard humans as part of larger passive groups (of class or ethnicity), or as anonymous drivers of pollution or of urban development (Alberti 2005; Pickett et al. 2008). Few studies focus on the governance of ecosystem services of larger urban landscapes and regions. In this article we synthesize a set of case studies from the urban landscape of Stockholm, Sweden, with the aim to explore a social network structure for governance that can secure the flow of ecosystem services. The concept of ‘network’ governance takes into account all actor groups and non-linear relations that may influence outcomes in an uncertain world, including government authorities as well as citizens and groups in civil-society (Sörensen and Torfing 2006; Duit and Galaz 2008; Galaz et al. 2008). Such network governance is part of adaptive governance (Dietz et al. 2003; Folke et al. 2005), and focus here is on how the network structure allows for ecosystem management on the ground, and for dealing with scale mismatches (Olsson et al. 2007). It includes actor groups on multiple levels in society and active on various spatial scales in the landscape, their patterns of interaction, as well as rules-in-use and social practices in policy, planning and ecosystem management.

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Adaptive Co-management and Adaptive governance are two analytical frameworks that has been developed to analyze ecosystem management in multi-level governance contexts (Gunderson and Holling 2002; Berkes et al. 2003; Olsson et al. 2004; Folke et al. 2005). These frameworks, which hitherto have been less applied in urban landscapes, argue for a general shift of paradigms towards a focus on social-ecological resilience. Resilience is defined as the ability to assimilate disturbance without crossing thresholds into a different domain of attraction, with different controls on structure and function (Holling 1978; Folke 2006). Instead of single-species and the control of a few selected variables (Holling and Meffe 1996), governance should take holistic approaches that acknowledge the inherent uncertainty of social-ecological systems (Berkes et al. 2003; Folke et al. 2005). Ecosystem management should focus on ecological processes (e.g. nutrient flows and pollination) and on functional groups of species that play complementary roles in facilitating these processes (Nyström and Folke 2001), as well as on processes that transcends scales in space and time (Folke et al. 1998; Cumming et al. 2006). Inspired by this literature two criteria for governance of resilience are used in this paper; 1) *sustaining ecosystem functioning*, i.e. increasing the ability for urban ecosystems to regenerate through ecological processes and structures at multiple scales, 2) *creating and maintaining flexibility*, i.e. the ability to switch between of i) preparing for change, and to ii) responding to change.

Adaptive governance depend on several social processes, for instance trust, conflict resolution, knowledge integration, and vision building (e.g. Folke et al. 2005; Olsson et al. 2007). However, all of these partly depend on creating and sustaining social relations in networks of information sharing (Bodin et al. 2006a; Manring 2007). In this article we therefore focus on social networks, and especially on the structure of social networks, i.e. the patterns of mutual relations (Wasserman and Faust 1994). Although a network in itself does not ‘do’ or ‘learn’ anything – only individuals are capable of this (Guenther and Newig *manuscript*) – we can by uncovering the ‘architecture’ of information flows bring greater clarity into the structural factors that facilitate or constrain governance with the aim to sustain the flow of ecosystem services (Schneider et al. 2003; Bodin and Norberg 2005; Crona and Bodin 2006; Prell et al. forthcoming; Ernstson et al. 2008). This paper combines analyses of the social network structure of governance with an analysis of ecological scales (Cumming et al. 2006; Olsson et al. 2007), and the goal is to explore a spatially explicit model of governance that can overcome scale mismatches, and contribute to solutions of how to battle further erosion of ecosystem services.

The paper is organized as follows; we start by a short description of the case studies that has been synthesized here, followed by an account of the methodology. In the results we show that urban green areas that allow citizens to take active part in the actual management of ecosystem services play important roles in the generation of ecosystem services. However, such arenas are currently undervalued in Stockholm. There are mismatches here that are caused by many unfortunate features such as that the mid-scale of ecological processes is unattended, and that cross-scale practice in sharing of information between various actor groups is lacking.

The discussion revolves around how to improve a social network structure of governance by facilitating the emergence of *scale-crossing brokers*, which link disconnected actor groups that take part in ecosystem management at different spatial and societal scales, and how their scale crossing practice can enhance flexibility.

### Short Description of Case Studies

Our synthesis is based on seven case studies from the urban landscape of Stockholm, Sweden (Figure 1) published in separate papers (Table 1). The individual studies focused on different aspects of and management of green areas in Stockholm and generated both social and ecological data in order to capture the dynamics of social-ecological processes. Ecological data focused on functional groups (especially pollinators, seed dispersers, and insectivores) and were generated through field surveys of birds and bumblebees, complemented with ecological landscape analysis based on land cover structure from satellite images and network models. Social data were generated through engaging with different actors at different scales using different methodological tools such as text analyses, questionnaires and interviews (Figure 1). Actors included regional and municipal agencies, cemetery and park managers employed by the public or private sector, and civil society groups such as allotment garden associations, outdoor life associations, boating clubs and cultural-history and nature conservation groups. We refer to individual papers for detailed information. In the results section we refer to the case studies with their Roman numerals (I-VII) as given in Table 1.

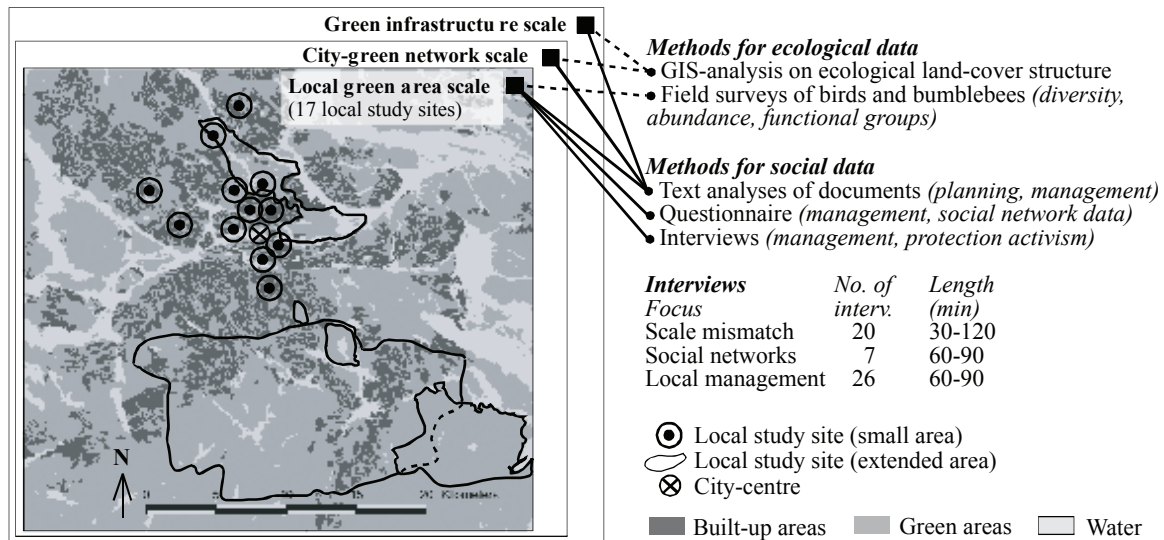
**Table 1.** The table shows the empirical case studies synthesized in this paper. The numbers are used in the main text to clarify results from the case studies. Number VI and VII were primarily carried out by colleagues from the same research group.

<i>No.</i>	<i>Publication</i>	<i>Short description of study</i>
I.	Barthel et al. 2005 Barthel 2006 Barthel et al. <i>submitted</i> .	Historical land use analysis of stake-holders, property rights, and management of large urban park (the National Urban Park; NUP), and studies of social-ecological memory in local communities of allotment gardening.
II.	Borgström et al. 2006	Comparative study of ecosystem management in five local green areas: large green area (NUP), large cemetery, nature reserve, urban forest, and a watershed.
III.	Andersson et al. 2007	Comparative study of management practices between different actor groups: cemetery managers, urban park managers, and allotment gardeners.
IV.	Ernstson and Sörlin 2009 Ernstson et al. 2008	Social network analysis of local urban movement protecting a large urban green area (NUP) followed by value creation analysis.
V.	Andersson and Bodin in press	Ecological network analysis of bird species movements.
VI.	Lundberg et al. 2008	Mobile link analysis of the Euroasian Jay and oak forest generation for a large urban green area (NUP).
VII.	Colding et al. 2006	Spatial assessment of different types of urban green areas with focus on allotment gardens, domestic gardens, and golf courses vs. protected areas



## 2. Methodology: A Framework for Social-Ecological Synthesis

This paper synthesizes a set of results from different case studies conducted in the same landscape (figure 1). Our methodology for synthesizing individual case studies is based on a theoretical framework of social-ecological systems, with focus on spatial scales, and how to govern them (Berkes and Folke 1998; Gunderson and Holling 2002; Folke et al. 2005), in combination with network models conducive for adaptive governance (Newman and Dale 2005; Bodin et al. 2006a; Guenther and Newig manuscript).



**Figure 1.** The map shows Stockholm Metropolitan Area marked with 17 local study sites and the methods used for data generation. Stockholm is situated at the boundary between the northern hemisphere boreal zone and the mid-European nemoral zone, and at the outlet of the freshwater lake Mälaren into the brackish Baltic Sea (59°20'N, 18°05'E). The physical landscape is shaped by the last glacial period 10.000 years ago and consists of fissured bedrock and clay covered valleys. The small scale rough terrain and the climatic conditions convey a relatively high biodiversity (CAB 2007). Stockholm hosts a current population of 1.2 million people, and it is the most rapidly growing and most densely populated region in Sweden with 2500 inhabitants/km<sup>2</sup> (SCB 2002). The case studies used different methods to generate data on different ecological scales.

Through this framework, which we elaborate below, we could identify scale mismatches, assess the criteria of ecosystem functioning and flexibility, and come with suggestions of necessary changes. Although the framework is new, it is in line with other approaches to analyze governance of social-ecological systems (e.g. Hanna et al. 1996; Berkes and Folke 1998; Olsson and Folke 2001; Cundill et al. 2005; Hahn et al. 2006; Young et al. 2006). It does not however cover other issues of adaptive governance such as the roles of institutional redundancy, polycentrism and conflict resolution mechanisms (Berkes Low et al. 2003; Dietz et al. 2003; Ostrom et al. 2005; Olsson et al. 2007; Ostrom et al. 2007; Galaz et al. 2008).

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Ecological scales are context sensitive and difficult to readily define in practice. Our aim was to identify, guided by theory and empirical measurements, those ecological scales most suitable for purposeful monitoring as outlined by Cumming et al. (2006), and which are relevant for ecosystem services that support the ability for urban ecosystems to regenerate, including pollination and seed dispersal. In theory ecological scales are viewed as hierarchically and dynamically linked (Gunderson and Holling 2002); interactions between parts in ecosystems are nonlinear and local, and constrained by larger scales, but local interactions may have emergent effects that could influence other scales and the system as a whole (Ibid.; Pickett et al. 2008). Different interactions will be important on different scales, e.g. interactions such as competition are local while resource use and population dynamics occur on landscape or regional scales. One key to finding the relevant scales for management is to understand how different organisms perceive and interact with the landscape (Hostetler and Holling 2001; Farina and Belgrano 2006; Lundberg et al. 2008). With this in mind, lower scales are assessed through analyzing patch quality and inter and intra species interactions, while greater scales are dependent on aspects of configuration, such as landscape supplementation and complementation, and neighbouring effects (e.g. Dunning 1992). At even larger spatial and temporal scales, dispersal corridors and sink-source dynamics become of importance (ibid.). Another issue is the scales and dynamics of disturbances, and in cities these are often caused or controlled by humans and should therefore be addressed from a social-ecological perspective (Pickett et al. 2008).

Just as ecological patches are part of greater scale patterns (Alberti 2005), social actors are part of emergent social network structures (Wasserman and Faust 1994). Bodin, Crona, and Ernstson (2006a) have outlined a network model conducive for adaptive governance. Others have pointed to similar models (Newman and Dale 2005; Guenther and Newig manuscript); what we do is to complement this model with information on ecological scales, so as to engage in a holistic analysis of a linked social-ecological system. Our framework consists of separate actor groups that interact with each other and the ecosystem at different spatial scales. They have strong internal ties, and weaker bridging ties to other actor groups (i.e. they meet less frequently or less intensely with them). Strong ties in communities of practice (Wenger 1998) support long-term capturing of place specific information (Barthel et al., *submitted*), while weak ties are important in spreading information over greater distances in the network (Granovetter 1973). Weak ties therefore play a crucial role in preparing for innovation and adaptation to new situations (ibid.), by breaking up closed group thinking and practice (Oh et al. 2004; Scheffer and Westley 2007).

In social networks there are sometimes brokerage positions between actor groups that are not directly linked (Burt 1992; Bebbington 1997; Olsson et al. 2007). In our framework it is important that these positions are filled by *scale-crossing brokers* that link disconnected actor groups that take part in management at different spatial scales. The main objective of the brokers is to facilitate sharing of captured and retained scale specific information.

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The reason for why this network structure can facilitate adaptive governance is that it strikes a balance between centralization (for effective collective action) and decentralized modularity (for a distributed diversity of autonomous and localized knowledge generation), which will be further discussed in section 4.

### **3. Results from the Synthesis**

The main finding from the synthesis is that there are several features of governance that can be improved. Currently, governance of urban green areas is split up with limited sharing of information between separate sectors and state agencies, and goals focus often on to uphold certain user values rather than sustaining ecosystem services that support ecological regeneration. Communication between state agencies and actor groups of civil society can be enhanced. Local actor groups that take part in management practice on the ground, which support the generation of ecosystem services, are not sufficiently acknowledged or engaged with by state agencies, which results in missed possibilities to learn about cross-scale ecological processes. Moreover, and central for the discussion below, the important mid-scale of urban ecosystem processes, referred to here as city-green networks, is not addressed by any actor group engaged in governance (see table 2).

#### **History and current governance**

Most of Stockholm's ecosystems are remnants from cultural usage and shaped by humans over the millennia, and ecosystem services generated today can be considered as emergent from a long-term social-ecological interaction or co-evolution (I). It is thus important to recognize that different actors with different objectives have created different ecological conditions, which in turn has increased the diversity of green areas and affected species composition, ecological functions and consequently the production of ecosystem services (I; II; III; VI; VII). Thus, continued management is needed to uphold the flow of urban ecosystem services (I).

Municipalities (state agencies) hold a key role in planning and management of urban green areas. Several efforts to engage in collaboration in ecosystem management has been launched by the Stockholm municipality (Stockholm Stad 2003), for instance educational projects with park and street managers and private entrepreneurs, as well as restoration projects in collaboration with groups in civil society, including ornithological associations and nature protection organizations. Further co-management examples are wetlands, urban forests, local neighborhoods and gardens managed by way of user-group contracts (*swe. 'brukaravtal'*)(I). However, our case studies indicate that these efforts seem to lack an overall strategy of how emergent social networks could be used for dealing with scale mis-matches and management of ecosystem services across the landscape. For instance user-group contracts are about management rights on short term basis granted by state agencies to local actors which comes with a set of regulations. It rarely involves meeting in arenas of dialogues and negotiation and of sharing experiences. Below we elaborate further features of mismatches in current green governance.

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## Features of scale-mismatches in Stockholm

There are many possible features for misfits and scale mismatches in Stockholm. One feature is due to the fact that municipalities hold monopoly of spatial planning, which tends to erect barriers that hinder cross-border cooperation between municipalities. Management of urban green space in Stockholm is formally organized by the municipalities according to user purposes. This has influenced the way many managers employed by municipalities, such as park and cemetery managers, perceive their local green area. Instead of seeing them as part of an ecologically linked landscape they are seen as belonging to a group of areas assigned to the same user classification (II; cf. Sandström et al. 2006). Cemetery managers for example, tend to form stronger social ties with other cemetery managers, and interact less with actors from adjacent green areas. The same is true for allotment gardens, which are linked with national and regional allotment unions (I). This indicates low ability to synchronize management to provide complementary habitats of ecosystem service providers, as argued by Colding (2007). Our studies of a selected set of urban parks and nature reserves indicate that there is an awareness of the importance of management at multiple spatial scales, but the tendency is to ignore interactions across scales (II), which we interpret as a limited understanding of cross-scale ecosystem dynamics.

One central finding is that a large proportion of urban green areas are ecologically undervalued due to the narrow definition used by authorities (VII; Lundgren and Alm 2001). Local green areas such as allotment gardens, golf courses and private home gardens are sometimes classified as “developed land” and not recognized for their ecological roles (VII), which goes in accordance with findings in Baltimore (Pickett and Cadenasso 2008). And hence, there is limited dialogue about ecosystem management between managers of ‘developed land’ and managers and planners employed by state agencies. This result in serious scale-mismatches of current management since local green areas facilitating cross-scale movement of species are ignored (III).

Other features for scale mis-matches are the goal as well as the methods used by management authorities, as they focuses mainly to facilitate large scale ecological flows within the whole green infrastructure, and to preserve selected local green areas where red listed species or high biological diversity have been recorded (VII). Moreover, the general lack of monitoring and evaluation of the management that is performed impedes trial-and error learning (II; Gunderson et al. 1995, Busch et al. 1995).

There are scale mis-matches that relate to capturing of experience of local change. Some local actor groups hold an important role in supporting the generation of ecosystem services but are nevertheless ignored by state agencies (I; III). For instance, allotment gardeners, bird watching associations, cemetery managers (I; III) and even urban golf course managers (VII), have the capacity to capture fine-tuned and continuous ecosystem feedback necessary for engaging in adaptive management, since they continuously monitor ecosystem processes (Holling 1978).

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When comparing employed personnel of cemeteries and urban parks with voluntary allotment gardeners, the latter group exhibited greater local ecological knowledge together with the widest range of management practices that offered protection of species and improved habitat to sustain pollination and seed dispersal processes (III). In allotment gardens there are means by which knowledge, experience and practice about how to manage a local ecosystem is retained, stored, modified and transmitted through time. This is an emergent structure of communities of practice (Wenger 1998), and it is defined here as social-ecological memory (I). A pre-requisite for such qualities to emerge is however, long term property rights, as the emergence of social-ecological memory is dependent on the time depth of lived experience (I). Social-ecological memory is a quality of communities of practice that take part in management on the ground, which enables individual managers to address underlying ecosystem processes behind many ecosystem services, and the quality by which they are capable to adapt to gradual change and retain experiences and modify practices in relation to a constantly changing world (I; III; Scott 1988). Moreover civil society actor groups have also shown to influence urban ecosystem by protecting them from exploitation. Indirectly this influences ecosystem functioning by changing the patterns of urban development (IV). It is reasonable to think that such local actor groups are prime candidates for capturing and retaining practices of importance to prepare for ecosystem disturbance (I).

However, even though some of local actor groups hold such qualities, they often seem to be ignorant of ecological processes that transcend their focus area. Municipal managers and planners hold less knowledge on site specific ecological processes compared to some local actor groups, but hold the missing landscape perspective (III).

### Connectivity between ecosystems of the urban landscape

An important consequence of the expanding city is that most green areas are small, which increases the significance of spatial structure, i.e. the habitat suitability of a patch is to a large extent dependent on its surroundings. Some species become dependent on small scale networks of one type of green areas (V), while others need access to several different types (VII). The small size of green areas also increases the probability that many organisms will exhibit meta-population dynamics with local extinction and re-colonization as shown by others in Stockholm (Mörtberg 2001) and elsewhere (Reale and Blair 2005). At a larger scale a system of ‘green wedges’, remain partly due to the city’s transport infrastructure and to land allocations. These are recognized by state agencies (Stockholm stad 2003) as providing ecological connectivity at a larger scale thus potentially replenishing sink populations of local green areas (cf. Sandström et al. 2006, cf. Crooks et al. 2004).

Based on empirical ecological inventories and on the possible features for scale mismatches we suggest that there are at least three relevant ecological scales for governance aiming to facilitate management of ecosystem services; *local green areas*, *regional green infrastructure*, and at the mid-scale, linking hierarchically between the other two, *city-green networks*. Our analysis of the connectivity and complementarities between ecosystem of the urban landscape shows that the mid-scale of the city-green network to a large extent determine whether different species are present or not (V; VI).

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In comparison to the other two ecological scales, city-green networks are understudied, and we found no actors that explicitly address them, although candidates exist. With a somewhat changed focus municipal agencies, municipal ecologists, and/or umbrella organizations from civil-society could address the ignored city-green network scale, as well as engage in networking between current dis-connected actor groups

### Implications of mis-matches

The above result show many possible features for the scale mismatches in the urban landscape of Stockholm. In Table 2 we have summarized these and the implications they might have for governance of Stockholm's green areas. The table also provide a set of suggestions for how to improve the social network structure of governance. In the following we discuss some features of the alternative governance.

**Table 2.** The table summarizes features of scale mismatches and the implication for current governance, followed with suggestions for improvements. We believe these suggestions could provide conceptual maps and diagnostic tools for analyzing governance of ecosystem services in other urban landscapes as well.

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#### *Findings from synthesis*

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1. Management is divided between separate sectors and state agencies and based on upholding certain user classified values rather than sustaining ecosystem processes in the landscape.
2. There are at least three separable ecological spatial scales of importance for governance: local green areas, city-green networks, and the green infrastructure.
3. One important ecological scale is not accounted for (city-green networks) and cross-scale dynamics are missed due to lack of information flows between actor groups engaged on different spatial scales and on different levels of society.
4. Actor groups from civil society with capacities for management and protection of local green areas are not sufficiently acknowledged or engaged with by state agencies, or treated on an ad-hoc basis.
5. Some social networks span across space (but tend to stretch only within actor groups).
6. Some candidates for scale-crossing brokers exist.

#### *Effects on current governance*

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1. Low flexibility for adapting to emergent ecological properties due to rigid sector divisions and strong administrative borders, paralleled with poor communication between most actors.
2. Unawareness of ecological cross-scale dynamics and ignorance of setting ecosystem services as objective for green governance.
3. No purposive governance at the scale of the city-green networks.

#### *Suggestions for alternative social network structure of ecosystem governance*

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1. Focus on at least three spatial scales; local green areas, city-green networks, regional green infrastructure
  2. (a) Include local actors from civil society, and (b) introduce scale-dependent responsibilities for all actors, while (c) appoint mid-scale actors responsible for the governance of city-green networks.
  3. Facilitate the emergence of scale-crossing brokers with knowledge of ecological processes and with a holistic landscape view. Their task is to (a) link disconnected actor groups on multiple spatial scales, (b) sustain and support local actors (i.e. sustain network diversity), and (c) coordinate collaborative action for responding to disturbance.
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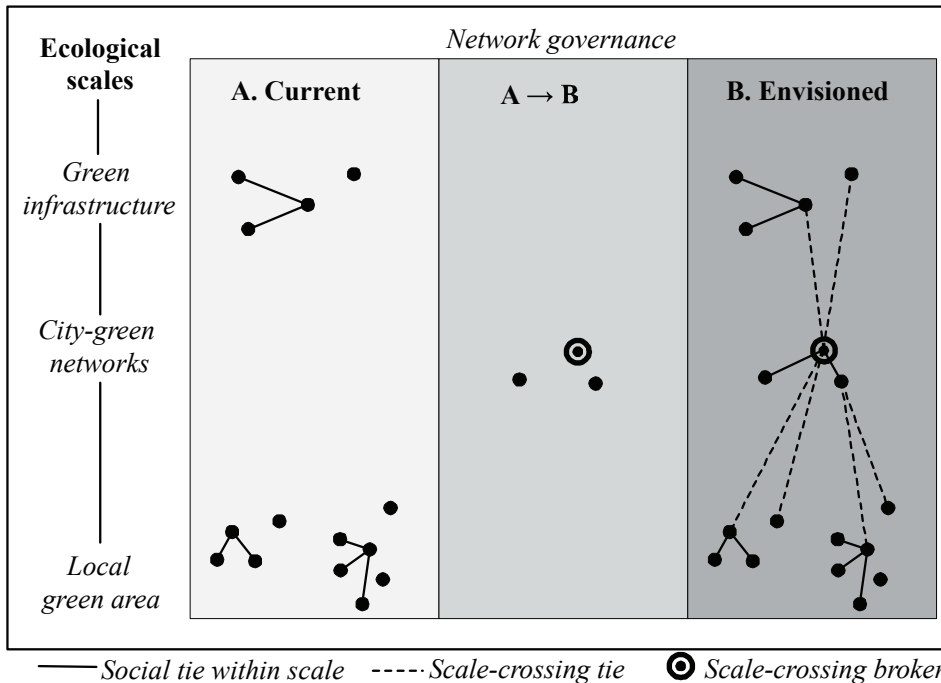
#### **4. Envisioning an alternative network structure for improved ecosystem management**

In this section we will analyze and discuss the findings and implications, and explore governance of resilience with the aim to uphold the flow of urban ecosystem services. One new priority of urban ecosystem governance should be the provision of ecosystem services, i.e. the capacity of ecosystems to deliver benefits to citizens. This would acknowledge already existing recreational, cultural and esthetic and open space values, but would need complementation by addressing ecological services that support ecosystem renewal.

A new adaptive governance regime that support ecosystem management should therefore be organized along the three ecological scales as we suggested earlier, in combination with development of means to facilitate exchange of information between actors at the different ecological scales. The aim of such governance is to enable different actors to address ecological objectives at their appropriate scales while simultaneously being open for cross-scale coordination of collaborative activities. We suggest therefore that education and appointment of mid-scale actor groups as well as scale-crossing brokers are of central importance for enhancing the social network structure of green area governance in this urban landscape (Figure 3). We argue below that this would enable scale awareness as well as enhance flexibility of governance (Table 2). These suggestions implicate to open up the current management mainly built around state agencies, for deliberative partnerships with civil-society and thus moving towards shared decision-making in governance of urban ecosystem services.

##### **Mid-scale managers and scale crossing brokers**

Since the mid-scale is currently not addressed, we argue for the need to facilitate the emergence of mid-scale actors responsible for the management of city-green networks. A city-green network consists of a mosaic of local green areas and green space that functions as dispersal corridors, which connects local green areas. Tools for identifying species specific city-green networks exist, based on network theory and modeling movement of species, digital mapping and inventories of biodiversity (Löfvenhaft et al. 2002; Andersson and Bodin in press; cf. Keitt et al. 1997; cf. Urban and Keitt 2001). In practice however, city-green networks are difficult to define since the landscape is used differently by different organisms. Thus the delimitation of the networks will depend on the ecosystem service(s) in focus. For instance, the city-green network relevant for pollination might be different from that of pest regulation or seed dispersal.



**Figure 3.** In comparison with the ecological scales we suggested for the studied social-ecological system, our results show that in the current governance (A) there are actors active on the lowest and highest ecological scale. By introducing actors responsible for city-green networks while at the same time introducing scale-crossing brokers (A→B), new governance (B) could emerge that better handle spatial and temporal mismatches between social and ecological processes.

The mid-scale actors should focus on to facilitate ecosystem management of the undervalued mid-scale. On one hand they should provide actor groups engaged on local management with an ecological context that make the most of the local heterogeneity. On the other hand, the mid-scale actors should hold a more dynamic view on landscape ecological functions by managing disturbance regimes, i.e. inducing disturbances to create local ecosystem collapses and allow for succession, consequently regenerating ecosystems and sustaining spatial resilience (Bengtsson et al. 2003). Such practices, e.g. cutting down patches of trees or even using fire, might be opposed by certain neighborhood groups and could therefore be difficult to apply in all local green areas. Thus, areas where such practices could be used should be identified and used to “fine-tune” the landscape matrix in space and time.

The role of the scale-crossing brokers is to focus on social relations of the network of governance. Since network structures cannot be controlled but are emergent, the brokers need to work as agents that strive to create and sustain a network structure that in turn facilitates processes that both prepare governance for change, and also processes that enhances the ability to respond to change. Manring (2007) talks appropriately of brokers as network “caretakers” and Thomas Hahn refer to “bridging organizations” as those actors that create and sustain purposeful social networks for collaboration (Hahn et al. 2006; Olsson et al. 2007). From a structural network perspective we can deepen the understanding of the practices of these actors. The practices of scale-crossing brokers for sustaining purposeful network structures can be divided in two parts.



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First, they need to network with *many* actors, with *different types of actors*, and finally, with actors at *different ecological scales*. Second, they should strive to sustain and increase actor diversity. Noteworthy is that these practices coincide with sustaining their own position.

As mentioned, scale-crossing brokerage is not just about social structure; it is also about social practice (Wenger 1998; Westley 2002). It requires enough legitimacy to influence the evolution of practice of different actors and to address conflicting interests (Ibid.). And at the same time it requires skills and practices to hold the structural position. The dilemma is about sustaining many ties, which means they are weak and provide less opportunity for trust and social learning, or to invest in stronger ties, which means to lose other ties and thus the brokerage position (Granovetter 1973). Scale-crossing brokers may well be organizations of many individuals that collaborate in solving this dilemma, in the literature such organizations is referred to as, institutional entrepreneurs (Westley and Vredenburg 1991) or bridging organizations (Hahn et al. 2006; Olsson et al. 2007). Maybe the most important quality of agency that scale-crossing brokers hold is ecological knowledge and a holistic landscape view based on ecological processes. This is needed if the broker is to capture and build understanding out of the diverse information received from different actors at different scales. Other practices important for the broker include leadership skills, trust building and social contracting (Westley et al. 2002; Hahn et al. 2006; Manring 2007; Olsson et al. 2007).

#### Enhancing flexibility of governance with scale crossing brokers

Ecosystem management requires flexible governance regimes which includes the ability to switch between different modes, for example switching between 1) preparing for disturbance by allowing for spatially distributed and diverse ways of capturing and storing place specific information of locally evolved dynamics, and to 2) igniting effective collective action for response to disturbance (van der Leuw 2000; Crumley 1994, 2000, 2003; Folke et al. 2005; Duit and Galaz 2008). Such flexibility partly is enabled or constrained by the structure of the social network of governance (Leavitt 1951; Diani 2003a; Ernstson et al. 2008).

Educating and appointing scale-crossing brokers of governance may increase flexibility. First, through linking actors on different scales, the coordination by scale-crossing brokers could decrease ecological mismatches and improve the functioning of ecosystems (Folke et al. 2005). Through such practice new and unique pathways for a diversity of actor groups to meet and exchange experiences can be created, which can nurture arenas of innovation for a greater potential range of purposeful actions (Burt 2003; Hahn et al. 2006). In such areas there is potential to draw on the diversity of social-ecological memories that has emerged in the different actor groups (Folke et al. 2003; Barthel et al. *submitted*). Here captured experience of change and successful adaptations from various parts of the landscape can be negotiated in debate for how to prepare for ongoing change and uncertain futures (Wenger 1998; Folke et al. 2003).

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An example of negotiation is about the ecosystem service of pollination where the location of nests of wild bees detected and desired by allotment gardeners can be passed on to municipal employees clearing bush lands. Several such learning arenas (Berkes et al. 2003; Olsson et al. 2004a; Fazey et al. 2006), could be initiated by scale-crossing brokers (Hahn et al. 2006), and then on later stages, other actor groups might continue, or close down such arenas (Danter et al. 2000; Manring 2007).

To draw on diverse social-ecological memories scale-crossing brokers must be able to sustain and increase the diversity of actors in the network (Olsson et al. 2006). This requires awareness of the general tendency of powerful actors to superimpose top down practises on less powerful actors (Agrawal and Ostrom 2001; Ostrom et al 2007), which threatens to erode valuable diversity of social practices in the network of governance. There are reasons to believe that decentralized networks of social diversity prepares the network prior change, only if there is autonomy for local actor groups to self organize (van der Leeuw 2000; Crumley 2003), meaning here self-monitored collective action assumed without being guided or controlled by an outside source (Westley 2002). Decentralized green area governance should therefore be accompanied by robust property rights that gain local actor groups rights and obligations (Agrawal and Ostrom 2001; Barthel et al. *submitted*; Colding 2009), and other conditions that generate self-organization in communities of practice (Wenger 1998). The task of recognizing gradual changes in ecosystem dynamics hence depends on the existence of diverse actors at different scales – from allotment gardeners and municipal ecologists to regional planning offices – that continuously perform their practices and generate lived experiences.

Scale crossing brokers can also enhance ability of governance to respond to disturbances, by taking central leadership for collective action (Leavitt 1951; Lin 1999; Agranoff and McGuire 2001; Westley 2002; Olsson et al. 2006). In fact, the notions of broker and the ones of network-leader, or institutional entrepreneur share similarities such as active ‘networking’ as a practice (Westley and Vredenburg 1991; Bardach 1998; Kooiman 1993; Burt 2003). From Burt (2003) we know that network wide information have a tendency to be concentrated to the broker, which enhances its ability to coordinate collective action in essential ways. Situated in a position where diverse flows of information and knowledge meet, including scientific and local experiential knowledge, the broker will have greater ability to create novel understandings and see new innovative opportunities (Burt 2003). In response to rapid change, it can take earlier action and find new collaborative solutions for novel situations. This effect rests upon that the brokerage position grants the broker more diverse and up-to-date information than any other actor in the network. In part it is the position between other knowledgeable and resourceful actors at different ecological scales that brings out such abilities (Ibid.). For example, if a pest-outbreak or a new invasive species is recognized and responded to locally by a allotment gardener, and which threatens to diffuse over wider landscapes, the broker could find financial means, social capital and engage experts and to guide further collective action. Hence, in such circumstances decision making becomes centralized and the scale-crossing broker takes on a leadership role for collective action in response to ecosystem disturbance. Such social processes have proven to influence the generation of ecosystem services by protection of a large urban park in Stockholm from exploitation (Ernstson et al. 2008; Ernstson and Sörlin; *in press*).

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Here a vast diversity of interest and user groups that articulated the values of this park in competition with other land use interest such as infrastructure, office and housing, was facilitated, articulated and expressed by an actor group with a central position in the network (Ibid.) This example also shows that such network leadership differs vastly in practice from conventional command-and-control style of hierarchical management (Agranoff and McGuire 2001; Westley 2002; Galaz et al. 2008).

Scale-crossing brokers are possible agents for navigating the social network structure between centralized collective action on the one hand and decentralized and the preservation of social diversity of local autonomous actor groups (rich modularity), on the other. We believe however, that the issue of how to switch between these modes needs further research. It is possible that such flexibility of governance lies in a combination of social practice, politics and of underlying world views of participants in governance (Wenger 1998; Westley 2002; Folke et al. 2003). It may be facilitated by scenario building exercises, including the construction of artifacts and shared narratives, and other ways that can increase values for such flexibility (cf. Callon 1986; Wenger 2000; Ernstson and Sörlin 2009). However, it may well be that there are trade-offs between the modes of collective action and rich modularity. In network theory, an assumption is that all social relations come with a cost, first for establishing it and then to sustain it (Granovetter 1973), which tends to direct information flows through established patterns of interaction (Diani 2003b).

Social network structure are consequently an outcome of localized interactions and no actor can fully control the whole emergent structure, but scale-crossing brokers may change at least parts of the network structure through interacting with new actors (ibid.). Such new interactions is what partly lies behind transformational changes when for instance an institutional entrepreneur or bridging organization invests time and effort in creating new links (Westley and Vredenburg 1991; Olsson et al. 2004b; Manring 2007). However, the idea that social network structure is an emergent property due to local interaction of costly relations also demonstrates its inertia, and why it is referred to as a 'structure' (Degenne and Forsé 1999). In Stockholm the same network structure that was effective for protection of a large urban park, might have hampered ecosystem management of the same park, as user groups with ecological knowledge were marginalized due to their peripheral network position (Ernstson et al, 2008). This serves as a good example of the duality between network structure and process; a structure effective for solving certain issues might simultaneously constrain solving other types of issues (Diani 2003b).

Although no scale-crossing brokers were identified in Stockholm potential candidates exist. Scale-crossing brokers and the actors responsible of managing city-green networks could appear to have similar positions and might even work in the same organizations. However, the latter has a clearer spatial responsibility with focus on a particular city-green network and engage more profoundly in ecosystem management, while the broker should focus on social networking.

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The brokerage position could be held by both individuals, and organizations from civil-society, as well as municipal agencies (Cash and Moser 2000; Olsson and Folke 2001; Westley et al. 2002; Hahn et al. 2006; Olsson et al. 2006; Moss and Wissen 2005) We found that candidates from all categories already exist in Stockholm.

## **5. Further explorations**

How do we identify social networks of governance that is able to ‘navigate’ the dynamic nature of multilevel and multi-scale interconnected social-ecological systems so as to secure the flow of urban ecosystem services? In this article we have shown how this pressing question can be addressed through synthesizing a set of case studies from Stockholm and compare them with a theoretical framework combining ecological scales and social network structure. To develop interdisciplinary frameworks of governance such as the one discussed here can, in the words of Manring (2007), provide “conceptual maps and diagnostic tools”. Generally, cities have predominately been viewed as social entities and produced an organizing logic that constrains urban green governance. We therefore believe that our results could be quite general and apply to urban green governance in other cities as well.

We like to express that our framework is explicit in identifying suitable ecological scales which have been less rigorously pursued by others (Pahl-Wostl et al. 2007; Manring 2007; Grimm et al. 2008), but argued as crucial by many (e.g. Cumming et al. 2006). Our analysis of the city-green network scale determined our exploration the social network structure of governance. But as it is difficult to define the delimitation of city-green networks due to that the landscape is perceived differently by different organisms, we leave it to future research to develop criteria for how to define city-green networks. A promising approach could be to base them on mobile links, i.e. species supporting ecosystem regeneration through their movement between separate areas (Nyström and Folke 2001; Lundberg and Moberg 2003; Bodin et al. 2006b; Lundberg et al. 2008), in combination with ideas on how to manage sets or “bundles” of ecosystem services in landscapes (Goldman et al. 2007; Nelson et al. 2008).

A question left unanswered in our analysis is the one about accountability (e.g. Agrawal and Ribot 1999; Bierman 2007). Scale-crossing brokers will have great social capital and power (Lin 1999; Crona 2006) that potentially can be used for self benefit or to navigate towards maintaining some ecosystem services in front of others or favoring certain types of actor groups and not others (Heynen 2003; Adger et al. 2006; Corbera et al. 2007). If scale-crossing brokers exercise their power in such ways, how and by whom are they held accountable? Who are legitimate scale-crossing brokers? Further intriguing research areas about the emerging field of adaptive governance and the needed flexibility for upholding the flow of ecosystem services may be cross-fertilized by such analyzes (McLaughlin and Dietz 2008; Ernstson 2008).

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