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Historical governance of ecosystem services through metropolitan spatial planning

A case study of how the regional plans of the Stockholm Metropolitan Area have dealt with ecosystem services, the "green wedges" and adaptive co-management

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ABSTRACT

Whilst recent social-ecological research has identified the need for incorporation of ecosystem services (ESS) and related adaptive governance strategies into urban planning policy, little attention of this sort has been directed to the study of metropolitan spatial planning. This thesis contributes to this gap through a historical document analysis of the regional plans of the Stockholm Metropolitan Area. The study examines how the regional plans have historically 1) addressed ESS, 2) used the concept of the "green wedges" of Stockholm to support ESS and, 3) enabled conditions that allow for adaptive co-management (AC-M). For the assessment of the policy intent regarding ESS, an analytical tool, the ESS Coding Protocol, was designed. The analysis shows that an ESS approach has developed over time, from inadvertently addressing some ESS to an increasing amount of policy considerations where ESS have been deliberately addressed. The "green wedges" have received increased attention and have become a valuable planning tool for the regionally interconnected green space and, thus, helped improve regional governance of ESS. Even though improvements have been made, many ESS have had late or no attention at all and the linkages between different ESS have been weakly considered. Furthermore, the regional plans have not facilitated conditions for the emergence of regionally spanning AC-M in the Stockholm Metropolitan Area. Conclusively, the present-day ESS approach needs to be extended by a pedagogical and comprehensive view of how different ESS are connected to each other, the functioning of the city and the well-being of the citizens. The findings also suggest the development of an adaptive ESS framework for future decision-making as well as that future regional plans should facilitate conditions for the emergence of AC-M. These implications can help improve social-ecological resilience in the Stockholm Metropolitan Area and advance the understanding of cross-scale interactions in urban systems.

Key words

Urban ecosystem services (ESS), metropolitan spatial planning, regional planning, Stockholm, green wedges, urban resilience, uncertainty, urban social-ecological systems, adaptive co-management, cross-scale interactions

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Acronyms

AC-M	Adaptive co-management
CAS	Complex adaptive systems
ESS	Ecosystem service/s
MA	Millennium Ecosystem Assessment
RP	Regional plan *(Regionplan)*
RUFS	Regional Development Plan *(Regional Utvecklingsplan för Stockholmsregionen)*
S-ES	Social-ecological system/s

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"Men svalans bo. Svalans rede av lera, saliv, gräs, fjädrar.

Twin Towers konstruktion av sten, malm, smält sand.

En fråga om att skruva upp volymen."

Excerpt from *Hallucinatur* by Vendela Fredricson (2009)

1 Introduction

This thesis examines how metropolitan spatial planning strategies in Stockholm have dealt with *ecosystem services* (ESS), green space interconnectedness and the extent to which an adaptive co-management approach has been taken. This is a critical gap in current scholarship that needs to be addressed to inform improved governance of urban ESS. This section of the thesis provides an overview of the context for and scope of the research.

1.1 Context

The *Brundtland report* (WCED 1987) calls for a sustainable development, i.e. to *"meet the needs and aspirations of the present without compromising with those of the future."* (Brundtland 1987, p.39) One of the key challenges is to manage natural resources in a way that sustains functioning ecosystems for their capacity to deliver ESS (e.g. Daily 1997; Folke et al 2004; MA 2005; Andersson 2006; Elmqvist et al. 2008). For their survival, all humans are dependent on them. The growing demands of an increasing and increasingly consuming population of the world have accelerated ecosystem change contributing to a decrease in the prevalence of ESS more rapidly than ever before during the last 50 years. The *Millennium Ecosystem Assessment* (MA) (2005) states that significant changes in policies, institutions and practices are needed in order to help reverse ecosystem degradation.

Today more than half of the human population lives in cities or metropolitan areas and this is increasing (UN 2008). It is acknowledged that the city is a resource effective mode of living, as densely populated areas consume less per capita than sparsely populated areas (Glaeser 2011). However, the natural resource consumption of the city require ecosystems hundredfold its own area (Rees and Wackernagel 1996; Folke et al. 1997) and city people need local ecosystems for their well-being (Bolund and Hunhammar 1999; Barthel et al. 2005). Thus, cities provide opportunities for sustainability and simultaneously a significant human-induced threat to global ecological well-being and also ultimately to functioning urban systems (e.g. MA 2005; Pickett et al. 2001; Andersson 2006; Elmqvist et al. 2008). Humans are the dominating species and inseparable social and natural processes shape the urban identity in an interlinked complex *social-ecological system* (S-ES) (Portugali 2000; Pickett et al. 2001). Therefore, when cities are discussed in terms of sustainability,

one of the important elements is the resilience of S-ES for the maintenance of a sustainable flow of ESS (Andersson 2006; Mäler et al. 2008). Land use competition and the inability of institutions to respond to rapid change can lead to a fragmentation of ecosystems, enhancing loss of biodiversity and the provision of ESS, with increased risk of weakened urban resilience (Pickett et al. 2001; Alberti 2005; Elmqvist et al. 2008; Ernstson et al. 2010a). The ESS that urban ecosystems still generate are crucial both for the well-being of the citizens and the livability of the city (Daily 1997; Bolund and Hunhammar 1999; Andersson 2006; Ernstson et al. 2010a). With adequate management that helps sustain interconnectedness between green areas from the city centre to surrounding nature as well as heterogeneity in land use, urban systems can maintain high levels of biodiversity (Collins et al. 2000; Elmqvist et al. 2004; Barthel et al. 2005). Yet, there is a global tendency that biodiversity and ESS are overlooked in urban planning (Elmqvist et al. 2008). Therefore, an ESS approach with thorough and deliberate considerations in relevant plans is advocated (e.g. MA 2005; Niemelä et al. 2010). However, for sustainable ESS governance, an equally important challenge is to more widely recognize cross-scale interactions on multiple spatial and temporal scales as well as functional scales in S-ES (Cumming et al. 2006; Ernstson et al. 2010a). Spatial and/or temporal mismatches between the scales of ecological processes and the scales of social organizational processes are inadequately addressed in most urban planning and associated regional policy tools (Borgström et al. 2006). There is limited understanding both concerning causes and actions to deal with these mismatches. However, the long-term resolution is considered to be the development of flexible learning institutions that can manage change and surprise (Cumming et al. 2006). One way of achieving this, not least for the avoidance of scale mismatches in the management of urban green space, is through so called *adaptive governance* strategies (Folke et al. 2005; Borgström et al. 2006; Ernstson et al. 2010a). Such strategies embrace uncertainty as a precondition in social-ecological management, and include testing a variety of knowledge systems as well as linking a diversity of institutions and actor groups across scales in social networks through so called *adaptive co-management* (AC-M) (Folke et al. 2005; Lebel et al. 2006).

There has been little detailed analysis of how metropolitan spatial planning has framed the management of ESS (Wilkinson 2010). This thesis contributes to addressing this gap through its historical analysis of ESS governance in the regional

plans of the Stockholm Metropolitan Area and thus informs assessment of the relevance of the ESS concept for urban governance. This is a useful contribution to ongoing efforts to improve our understanding of how ESS governance in urban systems can be improved.

1.2 The birth of metropolitan spatial planning

City planning evolved in Europe in the end of the 19th century as a new tool for the management of urban structure, with foundations in empirical knowledge and rationality. A comprehensive regional planning that considered the relation between urban and rural land as well as the idea of a core city surrounded by smaller suburban areas started to raise interest. Another important contribution to city planning was to reinforce the citizens' interaction with urban space, by incorporating knowledge and involvement from all parts of society as well as cooperation between different professions, scientists and other citizens. A declaration on urban planning, *Charta d'Athenès* (1933), proclaimed that the focal point of city planning should be to, based on scientific research, order the *functions* of habitation, working place, recreation and traffic. The idea of protective green zones surrounding the different functions would maximize air and light in urban space. Scholars that supported the declaration also meant that urban and rural land could not be viewed upon as two separate components, which implies that cities must be studied taking the entire region into account, i.e. the establishment of a regional plan was deemed necessary. The planning system should, in addition, consider the natural, social, economic and cultural factors, which are different for each specific case (Ahlberg and Johnson 2006).

Metropolitan spatial planning was first introduced in Stockholm in the 1920's when the need for coordinated inter-municipal development of certain planning issues was identified. Regional planning in document form, a policy measure in form of a regional plan with guiding recommendations for planning, made its entrance in 1936. In 1947, region planning was incorporated in Swedish Planning and Building Legislation (Plan- och bygglagen, PBL) (see also section *3.1.1*). The first legislatively instigated regional plan of Stockholm was established in 1958 and has followed by several more (RTK 2002).

1.3 The Stockholm Metropolitan Area

Stockholm County has an area of 6 519 km^2 with approximately 2 million inhabitants in 2009 and a population density of 310 inhabitants per km^2 (USK 2011). The city of Stockholm, partly built on islands, lies in the junction of fresh water lake Mälaren and brackish Baltic Sea with its archipelago in the east (Bolund and Hunhammar 1999). Covering 22 percent of the county area, ten "*green wedges"* pointing in between a radial rail bound infrastructure network, from the rural surroundings towards the city centre, make up an interconnected ecological structure (see *Figure 1*) (Bolund and Hunhammar 1999, Colding et al. 2006). The Stockholm Metropolitan Area holds many important ESS whose maintenance is

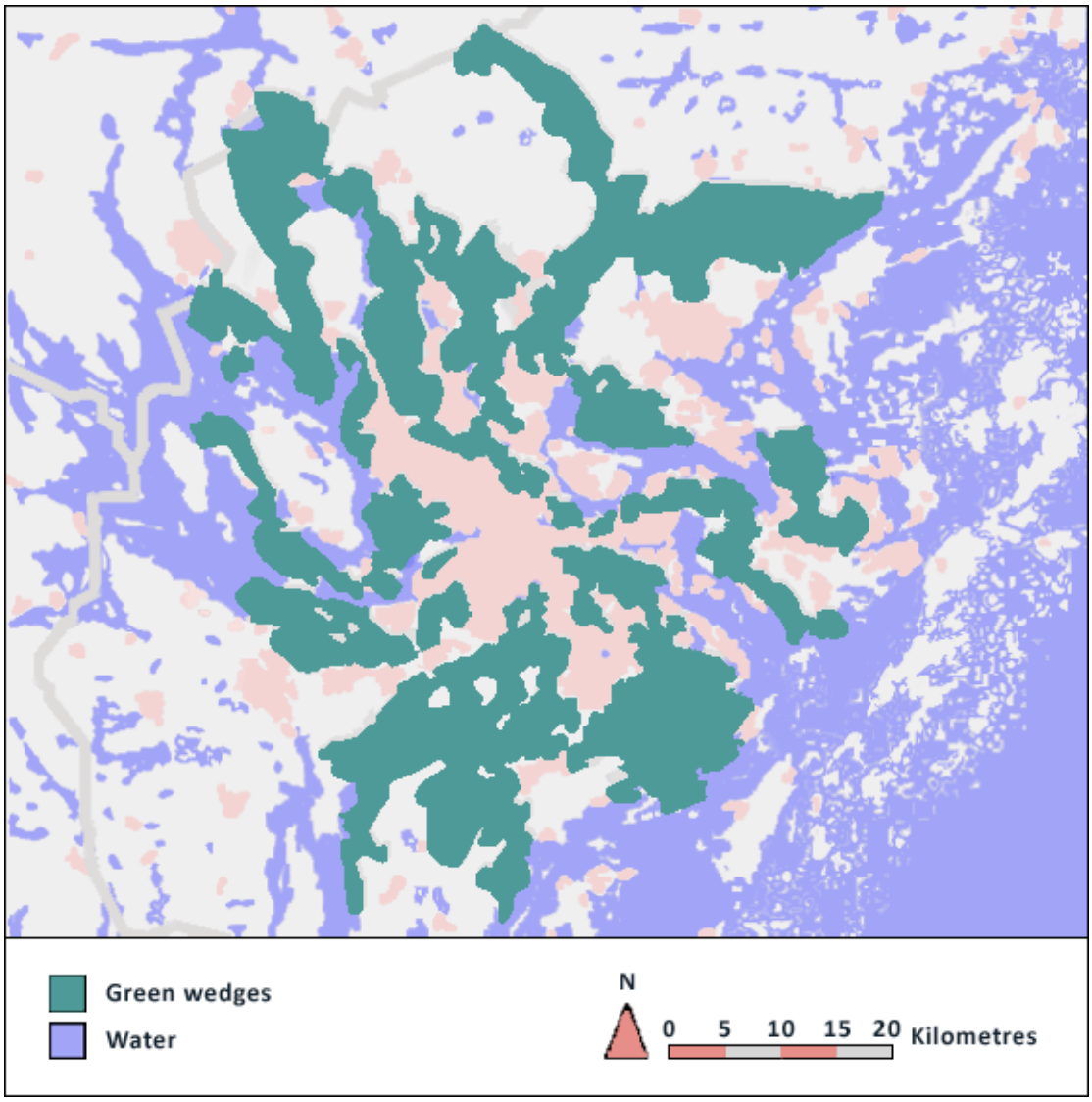

Figure 1. Map showing the approximate spatial dimensions of the "green wedges" in Stockholm County (Adapted from: Lantmaäteriet topographic map 1:50 000, 2002-11-15 item # M02–6278 in Colding et al. 2006 *and* Figure 2. in Ernstson et al. 2010a).

crucial, such as pollination, seed dispersal, provision of fresh water, sewage treatment, air quality regulation, climate regulation, recreation and health (e.g. Bolund and Hunhammar 1999; Ahrné et al. 2009; Ernstson et al. 2010a). In the last decades, the green space has successively become more fragmented and the size as well as the coherence of the green wedges has decreased. The entire region has suffered from ecosystem and biodiversity loss, which implies a risk for some ESS to be reduced (Colding et al. 2003 and 2006). There are arenas for AC-M in the region (Barthel et al. 2005; Ernstson et al. 2010a), but a lack of awareness concerning cross-scale interaction and ecological interconnectedness in the green space management of Stockholm is also recognized (Borgström et al. 2006; Ernstson et al. 2010a). Management of ESS on a regional scale is dealt with poorly, with inadequate understanding of the city as a complex S-ES (Colding et al. 2003; Borgström et al. 2006).

1.4 Problem statement

It is important to study governance of urban S-ES, since human-induced fragmentation of urban space enhances the risk for further loss of urban ESS and subsequently weakens the resilience of cities (MA 2005). Given the interdependency of social and ecological systems, it is not only important to deliberately manage ESS, but a consensus view amongst scholars suggests that institutions must be adaptive to change (e.g. Berkes and Folke 1998, Olsson et al. 2004; Armitage et al. 2009). The *Millennium Ecosystem Assessment* (MA) (2005) recommends that resilience thinking should be an important constituent of planning processes. Metropolitan spatial planning in the form of regional plans, serving as guidance tools for more local scale city planning, is a key to urban governance mechanisms (Ahlberg and Johnson 2006; Kreukels et al. 2002). It is important to understand how planning on regional scale can help improve ESS management through deliberate ESS considerations and concern for ecological interconnectedness (Niemelä et al. 2010). Nevertheless, since the city is a S-ES, it is equally important to understand how scales of social processes can be governed for dealing with uncertainty as well as for better acknowledging cross-scale interactions and ESS management (Ernstson et al. 2010a). There is a need for finding new insights for adaptive governance of urban S-ES and how higher institutions, such as metropolitan spatial planning, can contribute to the emergence of

AC-M (Folke et al. 2005; Armitage et al. 2009). Such aspects regarding metropolitan spatial planning are not addressed sufficiently in social-ecological literature. There is also a lack of useful tools that help incorporate implications of resilience theory into practical management. This thesis contributes to these gaps.

1.4 Research aim and questions

The aim of this thesis is to develop an understanding of how governance of ESS through metropolitan spatial planning in Stockholm has historically evolved. It seeks to explore how regional plans have dealt with ESS management.

Three research questions (RQ) have guided the study and are used to structure this thesis:

RQ 1: How have ecosystem services (ESS) been addressed over time?

RQ 2: How have the "green wedges" and green space interconnectedness been historically governed for the support of ESS?

RQ 3: How have conditions that allow for adaptive co-management (AC-M) developed over time?

The first RQ examines how metropolitan spatial planning strategies for the Stockholm Metropolitan Area have historically addressed ESS through written formulations.

The second RQ examines how metropolitan spatial planning strategies have taken the region's larger green space interconnectedness, the "green wedges", into account, and how this has supported ESS management.

The third RQ emanates from the view that urban social and ecological development is constantly faced with uncertainty due to non-linearity, which implies that management of cross-scale interactions and ESS desires systems of adaptive governance. Thus, it explores how metropolitan spatial planning has historically framed potential enabling conditions for AC-M to emerge.

This study is a necessary starting point in order to create an understanding of cross-scale interactions and the avoidance of scale mismatches as well as for providing a

basis for recommendations regarding the improvement of a more resilient governance of ESS in decision-making through metropolitan spatial planning.

Furthermore, this thesis seeks to contribute to the development of improved analytical tools for the study of ESS management. For the analysis of the first RQ regarding ESS, the *ESS Coding Protocol* was developed as well as tested through this research.

This thesis *also* contributes to the Formas[1] project 'GREEN WEDGES AS URBAN COMMONS: Applying a complex social-ecological system approach to sustainable urban planning' and is informed by and extends Cathy Wilkinson's doctoral work examining how the metropolitan spatial plans of Melbourne have dealt with ESS (Wilkinson 2010). The findings in this thesis will be subsequently used as a comparative case study to the Melbourne findings.

2 Theoretical framework

This section presents the theoretical approach that has been used for conducting the research regarding ESS governance through metropolitan spatial planning in this thesis. The first sub-section *2.1* explains the concept of ecosystem services and provides examples of recently developed analytical tools and frameworks that have the aim to facilitate the inclusion of ESS in decision-making. The second sub-section *2.2* moves on to discuss resilience of S-ES and how such insights, through the concepts of complex adaptive systems, cross-scale interactions and adaptive co-management, can be used in urban ESS governance.

2.1 Ecosystem services (ESS)

An *ecosystem* is the interaction of plants, animals, microorganisms and the non-living environment in one functional unit (MA 2005). *Ecosystem services* (ESS) are here defined by Daily (1997): *"…the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life."* (Daily 1997, p. 3). Human well-being is consequently dependent on the flow and maintenance of ESS. They are commonly

[1] The Swedish Research Councel Formas aims to *"promote and support basic research and need-driven research in the areas Environment, Agricultural Sciences and Spatial Planning"* (Department of Co-ordination and International Affairs 2011).

divided into four categories, depending on the type of benefit they provide humans with (Daily 1997; MA 2005):

- *Supporting services* are the services that underlie all other ESS, e.g. water cycling, nutrient cycles and biodiversity.
- *Provisioning services* are the services that maintain the production of goods, e.g. food, timber and fresh water.
- *Regulating services* are the services that regulate ecosystem processes, e.g. pollination, climate regulation and water purification.
- *Cultural services* are services that provide humans with intangible benefits and are of significant value for social and physical well-being, e.g. aesthetic and recreational values.

The MA (2005) points out that there are linkages between different categories of ESS and different constituents of human well-being, i.e. security, basic material for good life, health, good social relations and freedom of choice and action, and indicates the possibility for socioeconomic factors, e.g. urban planning, to mediate between the specific constituents. The linkages differ in strength both in terms of the linkage itself and in different ecosystems and regions. In addition to the condition of ESS, there are other drivers of change for human well-being. Indirect drivers of change include demographic, economic, socio-political, science and technology as well as cultural and religious ones. They often lead to enhancement of direct drivers of change, which in turn affect biodiversity and ESS. The indirect drivers of change are furthermore affected by the level of human well-being, which implies that it has the shape of a loop of positive feedback.

2.1.1 Analytical tools for the quantification of ESS in resource management

MA (2005) states that institutional and environmental frameworks in many cases should be improved for a more adequate management of ESS. The valuation of ESS has proven to be difficult to incorporate in resource management decision-making (Daily et al. 2000; MA 2005). Daily et al. (2009) recognises that it is at last time for the scientific community to deliver the knowledge and tools needed to make incorporation of ESS in decision-making easier. Efforts have been made to create

frameworks and analytical tools for the improvement of resource management, for instance the following:

- Daily et al. (2009) has presented a framework for the integration of ESS in decision-making. It identifies the multidimensional value of ESS, i.e. the continuous loop made up by links between decisions, ecosystems, ESS, values and institutions. Its aim is to help improve the design of institutions that guide resource management and policy, so that *"decisions made by individuals, communities, corporations and governments promote widely shared values"* (Daily et al. 2009, p. 23).
- Mäler et al. (2008) has developed an alternative classification of ESS, mainly in order to help integrate the concept of ESS in economic analyses as a tool for sustainable development. The classification simply merges the categories of supporting and regulating services to *intermediary services*, i.e. those that indirectly affect human well-being, and the categories of provisioning services and cultural services to *final services*, i.e. those that directly affect human well-being.
- Nelson et al. (2009) has presented a modelling tool; *Integrated Valuation of Ecosystem Services and Tradeoffs* (InVEST) that evaluates how alternative resource management choices across a specific landscape would impact ESS, biodiversity conservation and commodity production levels as well as trade-off patterns between them. It aims to guide policy makers and other stakeholders to more sustainable actions in an active land use management process. A case study described in the paper considered land use problems in a watershed in USA. Scenarios with a variety of ESS showed high values of biodiversity and scenarios with more development, however disregarding carbon-sequestration, had higher commodity production levels but lower values of biodiversity conservation and ESS.
- Raudsepp-Hearne et al. (2010) has developed a framework for the analysis of so called *ESS bundles*, i.e. the provision of multiple ESS in landscapes or ESS that often seem to appear parallel to each other. The need for such analysis emanates from the notion of ecosystem management where prioritisation of provisioning ESS has lead to trade-offs for other categories of ESS, particularly regulating ESS. The empirical demonstration conducted in the

study identifies a positive correlation between regulating ESS and ESS diversity. The method can be used in the analysis of whether the resource management of a specific landscape implies a desirable set of ESS or not.

As informed in section *1.4*, this thesis also seeks to contribute to the development of improved analytical tools. In this case a policy analysis tool, the *ESS Coding Protocol*, is presented and tested. The author of this thesis has co-developed it with Cathy Wilkinson and thesis student Nils Göransson. The protocol is designed for the analysis of the prevalence of ESS considerations in urban policies, with features emanating from the values of different ESS as described in MA (2005) (see section *3.3.2* for further description). It has also been used in a similar study of metropolitan spatial planning in Melbourne, Australia (Wilkinson 2010).

2.2 Resilience of social-ecological systems

Resilience was first described in a system ecology context by Holling (1973) as the magnitude of disturbance that a system can experience before it shifts into a different state with different controls on structure and function. Resilience as a concept has since then expanded and is discussed in a social-ecological context in terms of the capacity of the *social-ecological system* (S-ES) to adapt to and shape change, i.e. the adaptive capacity (Kates and Clark 1996; Berkes and Folke 1998; Folke 2006). If the S-ES is resilient, it can keep producing ESS for the well-being of humans (Walker and Salt 2006). In the last decade, the concept of resilience has been discussed for its implications for urban planning (e.g. Alberti and Marzluff 2004; Innes and Booher 2010) and recent attention has been drawn to the further broadening of urban resilience theory (Ernstson et al. 2010b). The following sub-sections will describe how resilience thinking can be applied to ESS governance.

2.2.1 Social-ecological systems (S-ES)

In ESS governance, it is important to recognize that humans are part of S-ES (Berkes et al. 1998). Economic and sociological, or socio-economic, features as well as the biophysical features of ecosystems are all components of an interlinked system. A change in land use management most probably implies changes elsewhere in the S-ES. That is, biophysical systems have impact on the life of human communities and humans have impact on biophysical systems (Walker and Salt 2006).

An urban system can be viewed upon as the most unmistakable verification that humans cannot separate themselves from ecological systems. Humans and the needs of the citizens dominate the city, but those needs cannot be fulfilled without taking notice to the needs of ecosystems and the services they provide us with; the city is a S-ES (Grimm et al. 2000; Alberti et al. 2003; Andersson 2006; Borgström et al. 2006). Actions and institutional development can reorganize the S-ES, taking cross-scale interactions into account, so that unwanted regime shifts can be avoided when the system is exposed to disturbance and changing conditions (Berkes and Folke 1998, Walker et al. 2004).

2.2.2 Complex adaptive systems (CAS) and uncertainty

S-ES and thus cities are a type of *complex adaptive systems* (CAS), which are characterized by *uncertainty* and are constantly adapting to their environment (Portugali 2000; Walker and Salt 2006; Duit and Galaz 2008). The implications of CAS theory are important in order to understand the cross-scale interactions between different actors and processes in the urban ESS governance system (Alberti and Marzluff 2004). All different types of systems consist of a certain amount of components, such as atoms, threads, people, plants, organs, fuel, institutions or cells. They can be built up of some of the listed components or of several others. The CAS has certain additional features. It consists of a high amount of components that are independent and constantly interact in a non-linear and unpredictable manner. Furthermore, there is a constant input through the change of existing or appearance of new components in the CAS (Levin 1999). The components act on local information about nearby components and interactions; *self-organization* occurs, which is the source for the patterns that feeds back and informs the components and interactions. This eventually leads to the characteristic uncertain behavior of the system (Levin 1999; Alberti and Marzluff 2004; Duit and Galaz 2008).

The many feedback mechanisms of a CAS occur at several different temporal and spatial scales (Alberti and Marzluff 2004). The role of time and space in CAS can be further understood through the lens of geographical phenomena and processes. In a traditional view, space is seen as *absolute*, i.e. that space and time is fixed and everything exists within its frame. In such view, the results of change in one component of the entire system can be predicted. Space can however also be seen as

relative, i.e. that everything that occurs in space is relative to proceedings towards more or less distant points as well as to what is relativized and by whom. In such view, space becomes inseparable from time, but external influences are not taken into account. A third way to view upon space is referred to as *relational* and acknowledges that external influences on space are embedded in specific processes or components over time. In reality, all of these views on space and time interact. That is, the relation between space and time is very difficult to measure (Harvey 1973 & 2006).

The implication of the above standing theory is that the understanding of one component in the CAS does not necessarily mean that outcomes for the entire system can be predicted, the system is rather characterized by uncertainty. Indirect initial changes in one component *can* lead to secondary feedback and eventually a non-linear change of the entire system from one stable state to another, i.e. a regime shift. This is central to the study of S-ES (Walker and Salt 2006). As mentioned, urban S-ES are a type of CAS, it actually consists of several sub-systems that all are complex and unpredictable (Alberti and Matzluff 2004). The implications of CAS theory to ESS governance of urban S-ES will be further examined in the following two sub-sections.

2.2.3 Cross-scale interactions in S-ES

For the understanding of urban systems, as for any other S-ES, accepting the views in the previous sub-section means a necessity of adopting the dynamics of how social and ecological processes interact on multiple *spatial*, *temporal* and *functional* scales; so called *cross-scale interactions* (Cash et al. 2006; Duit and Galaz 2008; Termeer et al. 2010). If this is not adequately governed, there is a risk for the *mismatch of scales*, which can lead to loss of ESS as well as the adaptive capacity of the S-ES (Cumming et al. 2006).

Spatial and temporal scales have slightly different meanings in social and ecological fields of research (Cumming et al. 2006). In terms of ecology, scales constitute spatial and temporal dimensions of ecological patterns and processes, i.e. the total area or time frame and spatial resolutions of the observed case (Turner et al. 2001). In terms of sociology, scales recognize social structures, i.e. organizational hierarchy from individuals to organizations, and social institutions, either regarding rules, legislation,

policies or norms that govern the spatial and temporal rights to resources and management responsibility (Cumming et al. 2006). This is not least relevant in an urban context (Cumming et al. 2006; Harvey 2006). In cross-scale interactions, spatial scales align when the spatial scale of management decisions and the spatial scale of ecosystem processes align appropriately. Similarly, temporal scales align when the temporal scale of management decisions and the temporal scale of ecosystem processes align appropriately (Cumming et al. 2006). For instance, the ESS that humans obtain from ecosystems are localized on various spatial scales but the ecosystems also evolve variously over time, and subsequently need various governance (Daily 1997; Alberti and Marzluff 2004; Cumming et al. 2006). As mentioned earlier, social and ecological scales are under complex influence of each other, which is caused by a variety of mechanisms: *"Human actions are influenced by institutions, by perceptions of how ecosystems function, and by perceptions of future change. Ecosystems in turn are structured by processes and feedbacks, including human influences, that arise from the interactions of organisms with their environment."* (Cumming et al. 2006, p. 2). Furthermore, social systems have, especially through humans that benefit from hierarchies, the power to deliberately influence ecosystems in a specific direction, whilst ecosystems cannot control their influence on society (Peterson 2000; Cumming et al. 2006). Functional scales can be described as the scales at which the magnitudes of social and ecological functions align, for instance regarding consumption and production. In other words, functional scales align when the hierarchies of social and ecological processes interact in a way that sustains the functioning of the S-ES. Such alignment implies for instance that ecosystems are able to provide society with ESS (Cumming et al. 2006).

Even if the scales of social and ecological processes sometimes are aligned, one of the major challenges that society is faced with is to manage the mismatch of scales (Levin 2000; Cash et al. 2006), which are particularly pronounced in urban S-ES (Borgström et al. 2006). When the scales of social organizational processes and the scales of ecological processes are poorly aligned, ecosystems are negatively affected by management decisions (Cumming et al. 2006). Resource management based on a traditional command-and-control approach, with the aim to reach an "optimal state" for ecosystems and to maintain the system in that state, has historically been considered best practice. Such management disregards uncertainty and cross-scale

interactions. That is, changes in management are expected to occur on the concerned scale without consequences on other scales, *and* assumes changes are either incremental or linear, i.e. cause-and-effect changes. As the greater S-ES changes in response to management, eventual secondary feedback can possibly lead to unwanted regime shifts, e.g. the degradation of the ecosystem ability to generate ESS (Portugali 2008; Walker and Salt 2006; Termeer et al. 2010). Such changes can be evidenced by a loss of adaptive capacity in both the social and ecological domains of the S-ES (Cumming et al. 2006).

2.2.4 Adaptive co-management (AC-M)

A consequence of the theoretical insights stated above is that there is a call for the consideration of CAS from a more resilient governance perspective of S-ES that would turn uncertainty to an opportunity for sustainable development (Alberti and Marzluff 2004; Folke et al. 2005), or as Folke et al. (2005) puts it: *"The challenge for the social-ecological system is to accept uncertainty, be prepared for change and surprise, and enhance the adaptive capacity to deal with disturbance."* (Folke et al. 2005, p. 464).

An a*daptive management* approach questions the focus on reaching and maintaining the optimal state of an ecosystem. Instead, it seeks to embrace uncertainty by constantly adjusting the understanding of the management system through the view of policies as hypotheses and management actions as experiments to test those hypotheses, i.e. learning-by-doing. In other words, it focuses on maintenance of an optimal management capacity, an adaptive capacity (Gunderson et al. 1995; Kates and Clark 1996; Walker and Salt 2006). Nevertheless, translation of such principles into practical management has had less emphasis (Armitage et al. 2009). *Co-management* is a social arrangement that addresses this, where the government and local resource users share power and responsibility in ecosystem management. However, as the following quote states; *"…adaptive management without collaboration lacks legitimacy […], co-management without learning-by-doing does not develop the ability to address emerging problems"* (Berkes 2009, p. 1698). This is addressed by recent *adaptive governance* theory, which focuses on social sources of adaptability in relation to ecosystem management and accepts ecological *and* social uncertainty as inherent to governance. Adaptive governance is operationalized through the self-organization of *adaptive co-management* (AC-M), which combines the learning-by-doing feature of adaptive

management and collaboration between multiple actors across multiple scales of *co-management*. Such polycentric institutional arrangements are suggested to be of significance for improved cross-scale interactions in ecosystem management (Olsson et al. 2004; Folke et al. 2005; Berkes 2009).

As any self-organizing process that constantly tries to adapt to its environment, AC-M is dependant on certain mechanisms in order to emerge. The basis for self-organization in this respect is social or collective memory, which implies the accumulated experience and history of the social and ecological system. Social memory is built up through social capital, which is referred to as the relationship between trust, social norms and social networks of actors possessing differentiated roles in regard to leadership, bridging abilities as well as knowledge. Social capital thereby increases institutional flexibility. Self-organization in turn, enhances learning and generates social capital. Furthermore, trust can take very long time to mature and can conversely, due to sudden shifts of intention of one single institution, be eroded very quickly. Consequently, self-organization is not fixed in absolute space and time, and will vary contextually in different S-ES. In other words, there is no recipe for the emergence of AC-M (Gladwell 2000; Pretty and Ward 2001; Folke et al. 2005; Armitage et al. 2009).

One way of encouraging AC-M is through devolution of management rights and power sharing that promotes participation (Folke et al. 2005), for instance through the establishment of so-called scale-crossing brokers that can facilitate interaction between actor groups (Ernstson et al. 2010a). As self-organization is a spontaneous bottom-up process, top-down legislation of co-management is considered problematic (Ruitenbeck and Cartier 2001). However, more recent studies suggest that higher central institutions must frame conditions that create opportunities for AC-M to emerge (e.g. Olsson et al. 2004; Folke et al. 2005; Armitage et al. 2009). Olsson et al. (2004) proposes that such facilitation of *"self-organizing processes of AC-M […] has the potential to […] make social-ecological systems more robust to change"* (Olsson et al. 2004, p. 75).

3 Methodology and research design

This section presents the methodological approach that has been used for conducting the research in this thesis. The first sub-section *3.1* describes the documents needed

for the case study. The following two sub-sections *3.2* and *3.3* describe respectively the method used for data collection and the strategies used when analyzing the data, both in the broader sense and in particular for each research question, e.g. through a presentation of the *ESS Coding Protocol* especially designed for this thesis. The last sub-section *3.4* then describes the limitations of the used methodology.

3.1 Case study description

In order to understand how ESS have been governed through metropolitan spatial planning in the Stockholm Metropolitan Area, policy documents with regional scale urban planning strategies were chosen as units of analysis. The documents are referred to as regional plans (regionplan, RP) or, lately, regional development plans (regional utvecklingsplan, RUFS). In Stockholm, these written policies have the aim to guide planning practices at more local scales with recommendations and they have no formal legislative power (Ahlberg and Johnsson 2006).

3.1.1 Legislative context of metropolitan spatial planning

Even though the first regional plan of Stockholm was established already in 1936, region planning was not incorporated into Swedish Planning and Building Legislation (Plan- och bygglagen, PBL) until 1947. The regional plan was considered to be a guiding tool for practitioners and planners at more local scales, and was appointed by the Swedish Government when they considered it necessary. The present version of PBL, in use since 1987, stipulates no further formal power to the regional plan. Some paragraphs have however been changed. For instance, according to the new legislation, it is the region planning body (Regionplaneorgan), i.e. the Stockholm County Council (Stockholms läns landsting), that has the authority to establish both investigations and an actual regional plan whenever they identify a need for further examination of land use or coordination of spatial planning matters concerning several municipalities (RTK 2002). Since 2001, the region planning documents for the Stockholm Metropolitan Area have been expanded to furthermore consider overall long-term societal development strategies, e.g. concerning economic development and the enhancement of the region's attractiveness. Thus, they are called regional development plans (Reigionplanekontoret - SLL 2010a).

3.1.2 Units of analysis

For this study, several planning documents concerning the Stockholm region with the potential to be part of an analysis of this kind were identified. The main decisive factor in the selection process was if the document was an officially adopted regional plan. Five documents were included on this basis. Other aspects taken into account include the consideration of impact in *real* planning, if the planning document was particularly interesting from a time perspective point of view and/or if it was not yet adopted. Three additional plans were included according to these criteria: *Regionplan för Stockholm med omnejd huvudsakligen avseende förortsområdet* (1936), *Skiss 66 till regionplan för Stockholmstrakten* (1967) and *Utställningsförslag till RUFS 2010* (2009) to the study. *Table 1* summarizes the eight selected documents:

Table 1. Units of analysis – the regional plans of the Stockholm Metropolitan Area

ACROYM	REGIONAL PLAN	DESCRIPTION
RP 1936	*Regionplan för Stockholm med omnejd huvudsakligen avseende förortsområdet* (1935)	A regional plan that mainly takes suburban planning issues into account.
RP 1958	*Förslag till regionplan för Stockholmstrakten* (1958)	Originally a proposal for the first legislatively instigated regional plan of Stockholm, but the same document was adopted as a regional plan in 1960 (RTK 2002), whereby it was named by the original title.
S 1966	*Skiss 66 till regionplan för Stockholmstrakten* (1967)	A sketch with the purpose to guide the development of a proper regional plan. It was chosen to this study, since literature (RTK 2002) points out that it was used widely in regional planning decisions and is considered to be a role model for modern Swedish metropolitan spatial planning.
RP 1973	*Regionplan 1973 för Stockholms län* (1976)	A regional plan adopted in *unknown date*.
RP 1978	*Regionplan 1978 för kommunerna i Stockholms län* (1982)	A regional plan adopted in *unknown date.*
RP 1991	*Regionplan 1991 för Stockholms län 1990-2020* (1995)	A regional plan adopted 13th of October 1992.
RUFS 2001	*Regional Utvecklingsplan 2001 för Stockholmsregionen (RUFS 2001)* (2002)	A regional development plan adopted in 2002.
RUFS 2010	*Utställningsförslag till RUFS 2010* (2009)	The final exhibition proposal for the 2010 regional development plan and was not yet adopted in the analysis stage of this study[2].

[2] RUFS 2010 was given legal force on 30. August 2010, i.e. became the sixth officially adopted regional plan (Regionplanekontoret - SLL 2010b).

3.2 Data Collection

The gathering of data was conducted through document analysis (Yin 2009), where the documents in this study, as presented above, are the larger-scale metropolitan spatial plans, or regional plans, of the Stockholm Metropolitan Area.

The purpose of this study was specifically to conduct a historical document analysis in order to determine the written policy intent. The outcome of the practitioners' interpretations of the policy was not the focus of this thesis. Therefore, the principle of triangulation (Yin 2009), i.e. the use of multiple sources of evidence in data collection for an analysis, was not appropriate for conducting this study. Instead, data has been verified in several ways:

- Thorough readings of all documents.
- Collaboration with colleagues working on a similar analysis for Melbourne.
- Development of detailed assessment of collected data in excel spreadsheets (see section *3.3.3*).
- Multiple reviews of gathered material for the selection of relevant and for each plan most representative data.

3.3 Data analysis

The broader analytical strategy used was content analysis (Yin 2009). The regional plans were reviewed to identify references to ESS, the "green wedges" and AC-M. In order to pursue this, two main analytical tools were applied; interpretive policy analysis and the ESS Coding Protocol, which was used to assess the relevant content regarding ESS and will be described below.

3.3.1 Interpretive policy analysis

Interpretive policy analysis (Yanow 2002) focuses on the meanings of a policy, i.e. on what values, feelings or beliefs they express, and how these meanings are transmitted to and interpreted by different "readers" of the policy. Therefore, conducting interpretive policy analysis implies that it is the interpretation of the researcher that determines the policy intent. For this thesis, the method was used in order to find formulations considering management of ESS, "green wedges" and AC-M as well as the contexts where those themes and patterns were discussed. The interpretation of the

data was carried out in different ways for each on research question, as described below.

For RQ1: "How have ecosystem services (ESS) been addressed over time?" formulations regarding ESS were collected and interpreted with the help of the ESS Coding Protocol, a procedure further described in section *3.3.2*. Due to the varying directness of the collected formulations, a separation was made into emic and etic codes (Crang 2005). Emic codes are themes and patterns explicitly identified by the author of the policy, while etic codes are those identified by the analyst as non-intentional meanings. In this thesis, emic codes are referred to as *direct* addressing of ESS, etic codes as *indirect* addressing of ESS.

For RQ 2: "How have the "green wedges" and green space interconnectedness been historically governed for the support of ESS?" formulations regarding the understanding of the regional green structure as an interconnected spatial planning matter in terms of "green wedges" were collected.

For RQ 3: "How have conditions that allow for adaptive co-management (AC-M) developed over time?" formulations regarding the themes of uncertainty and collaborative approaches to ecosystem management, were regarded. Given the difficulty to frame co-management in policies (Ruitenbeck and Cartier 2001) and the absence of a formula that establishes enabling conditions for AC-M in policies (Armitage et al. 2009), emphasis was on finding out if certain key concepts regarding uncertainty and collaborative approaches (see list below) were taken into account in the regional plans over time, rather than searching for a perfectly written strategy for the enabling of AC-M. The key assumption in answering RQ 3 was that if many of these concepts have been framed, and in a social-ecological context, the regional plans have an agenda of encouraging social planning approaches similar to AC-M. The following concepts were considered:

- *Uncertainty in space and time as a precondition for planning,* since embracing uncertainty is considered the foundation for adaptive management type of knowledge building (Folke et al. 2005). Here, key concepts such as uncertainty, unpredictability, adaptive capacity, scenario planning and long-term planning were regarded.
- *Linking actors across scales through collaborative approaches*, since it is

considered the best way of knowledge for learning through collective experiences of resource management, which ultimately helps the S-ES to prepare for change (Folke et al. 2005; Ernstson et al. 2010a). Here, key concepts such as co-management, social networks, social capital, collective (social) memory, coordination, shared management and local actor groups were regarded.

3.3.2 ESS Coding Protocol

In order to answer to RQ 1, i.e. to systemize the occurrence of different ESS in the metropolitan spatial plans and recording their evidence or absence, an additional analytical tool was needed: the *ESS Coding Protocol* (see *Appendix 1* for its full appearance). It was initiated by PhD student Cathy Wilkinson and designed by the author of this thesis, with input from fellow thesis student Nils Göransson and Cathy Wilkinson. The ESS used in the protocol were taken from or inspired by ESS described in MA (2005), *Nature's Services* (Daily 1997) and other scientific papers (Bolund and Hunhammar 1999; Maas et al. 2006). The four categories of ESS; *supporting services*, *provisioning services*, *regulating services* and *cultural services* were for further reference denoted respectively with *A*, *B*, *C* and *D*. Furthermore, the selection of ESS was not based on assumptions of those ESS that exist in Stockholm or Melbourne, since the intention of the protocol is to provide a tool for the analysis of policy documents in all metropolitan areas and at all urban scales as well as for other modes of governance than policy documents. Therefore, all ESS were included.

The ESS Coding Protocol was designed as a table of five columns, as follows:

- *SD* as in *sub-denotation*, where every specific ESS, in order to simplify and clarify referring to them, were provided with a number added to the ESS category reference letter at the front (A1, B2, C3 etc.). The numbers did not imply any order of valuation amongst the different ESS.
- *ESS* as in *ecosystem service/s*, which lists the names of each ESS.
- *NOTES*, which contains different types of clarifications regarding the particular ESS described, e.g. what output/benefits the ESS provides, or what its function is.

- *DIR*, as in *ESS directly addressed*, which provides a guide of key formulations, interpreted by the author as deliberate policy considerations regarding the particular ESS.
- *IND*, as in *ESS indirectly addressed*, which provides a guide of key formulations interpreted by the author as not addressing the ESS deliberately, i.e. with a supposed *positive* effect on the particular ESS if planning measures or policies are realized.

3.3.3 Excel spreadsheets and key quotes

A strategy was needed for the management of the extensive amount of data collected through the use of interpretive policy analysis (RQ 1,2 & 3) and the ESS Coding Protocol (RQ 1). The first step was to code relevant quotes for all research questions and insert them into separate *excel spreadsheets* for every regional plan, with research question specific colour schemes as well as additional coding columns for relevant information. The qualitative data was then retrieved through a selection of the most significant key quotes. A key quote was here defined as a formulation that captures relevant information regarding significant aspects of the concerned research question.

3.4 Limitations

The methodology used for conducting the study of this thesis implies following limitations:

- In the data collection, a focus on formulations and meanings of *positive* character was chosen, i.e. not on policies that *could* have negative effects on ESS, for instance most discussions concerning densification of urban development as well as the gearing of economic growth. This implies a possible loss of some ESS considerations and also a weakness in the analysis, since such information could provide interesting input to the discussion of what the intentions of the policy makers are.
- The ESS Coding Protocol was, as described above, created to fit the analysis for similar research. Efforts were made to design the protocol so that the risk of influence from the reader's values and interests while conducting the analysis would be minimized. Subsequently, the author has made all efforts

possible to reduce every risk of personal influence on the interpretations as well as on the selection of key quotes (see section *3.2*). Nevertheless, despite regard to both protocol design and intentions of the protocol user, different individuals commonly differ in their intuition regarding what symbols and findings are relevant. Therefore, the chosen method for analysis holds a risk for biased results, both concerning the identification of addressed ESS and selection of *relevant* key quotes. However, the thorough presentation of key formulations in the ESS Coding Protocol (see *Appendix 1*) helped to address this issue.

- Tangible criticism can be applied to the use of interpretive policy analysis, however at a slightly different scale. While such analysis focuses on symbols representing policy meanings, the analysis conducted for this thesis also seeks the etic codes, i.e. disregarding the original intentions of the policy maker. This refers to the indirect addressing of ESS and in other words to what consequences the symbols *could* imply in reality. In order to answer to that, the reader must use her own intuition and base of knowledge for the choice of *relevant* information. That indicates that this method too possesses a certain risk for biased results, despite according efforts made by the author to minimize such risk.
- All of the regional plans contain a regional map and occasionally other detailed maps, which often present a great amount of information, also regarding ESS. However, since the purpose of the study was specifically to conduct a historical document analysis in order to determine the written policy intent, focus has been on text.

4 Results RQ 1: How have ecosystem services (ESS) been addressed over time?

This section will present the findings for RQ 1: "How have ecosystem services (ESS) been addressed over time?" The ESS Coding Protocol has been used to collect the data. The first sub-section *4.1* will provide the historical appearance of ESS considerations in a general overview. The following sub-sections *4.2*, *4.3*, *4.4* and *4.5*, draw upon quantitative data and key quotes provided by the ESS Coding Protocol and will more specifically present respectively the historical regard to the services of each

ESS category; A) *supporting services*, B) *provisioning services*, C) *regulating services* and D) *cultural services*. Due to lack of room for the inclusion of all relevant quotes, a selection of important ESS formulations for each plan respectively are further listed in *Appendix 2*.

4.1 Overview of the appearance of considered ESS in regional plans

An overview of the amount of ESS that were directly or indirectly addressed in each plan (see *Figure 2*) shows that considerations of ESS has appeared to varying extent in the different regional plans of Stockholm. Thus, there is no incremental pattern of higher amount of considerations the later the plan is. For instance, of the five first regional plans, the third one, *S 1966*, had more than twice the amount of ESS directly

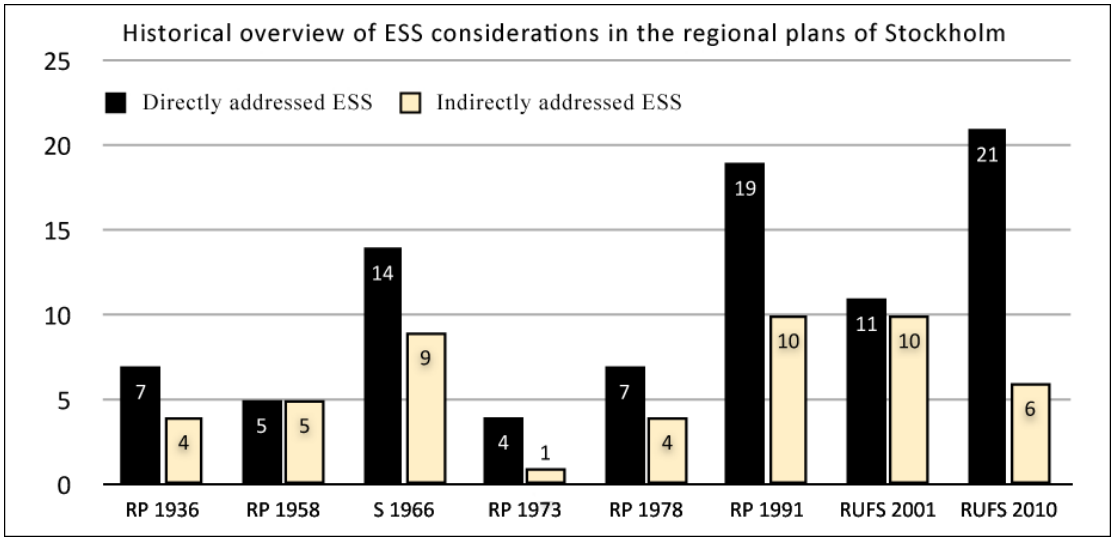

Figure 2. An overview of the amount of addressed ESS in each of the regional plans, where the left column of each regional plan shows directly addressed ESS and the right column shows indirectly addressed ESS. Notes: 1) Each ESS can be addressed both directly and indirectly. 2) The figure does not tell to which extent each ESS was considered.

considered than any of the other plans of that group, and the following one, *RP 1973*, had the lowest amount of ESS directly considered, only four, of all regional plans. Nevertheless, the results show that the three most recent plans, from the two last decades, held a considerably higher amount of ESS considered than the two former plans from the 1970's, which held respectively four and seven ESS addressed directly. It is also clear that of all plans, the latest one, *RUFS 2010*, had the highest amount of formulations that directly address ESS. Furthermore, the results indicate that with a higher amount of directly addressed ESS, the amount of indirectly

addressed ESS is also higher. Amongst the three most recent plans, the largest exception is the latest plan, *RUFS 2010*, with 15 more direct ESS considerations than indirect.

4.2 Appearance of supporting services

Table 1. Direct and indirect considerations regarding supporting services (A)

Regional plan / ESS	R 1936		R 1958		S 1966		R 1973		R 1978		R 1991		RUFS 2001		RUFS 2010	
	DIR	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*
A1 Water cycling	X				X								X		X	
A2 Sedimentary cycling																
A3a Nutrient cycling - the carbon cycle												X		X	X	X
A3b Nutrient cycling - the nitrogen cycle						X						X		X	X	X
A3c Nutrient cycling - the sulfur cycle						X						X		X		
A3d Nutrient cycling - the phosphorus cycle						X						X		X	X	X
A4 Primary production																
A5 Photosynthesis											X					
A6 Biodiversity	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
A7 Soil formation																
Type of consideration	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*
Total	**2**	*1*	**1**	*1*	**2**	*4*	**-**	*1*	**5**	*5*	**2**	*5*	**2**	*5*	**5**	*4*

Table 1. The table content shows a summary of which supporting services were addressed directly (**DIR**) or indirectly (*IND*) in each plan. It also shows the total number of supporting services addressed directly or indirectly in each plan.

The supporting services, i.e. the ESS that underlie all other ESS, were very scarcely considered through history (see *Table 1*). *Biodiversity (A6)* was addressed directly in all regional plans except *RP 1973,* and *water cycling (A1)* was addressed in two early as well as two late plans. *Photosynthesis (A5)*, *the nitrogen cycle (A3b)* and *the phosphorus cycle (A3d)* were framed directly in one plan each. The four nutrient cycles were in different constellations furthermore addressed indirectly in four plans, of which three were the latest ones. The remaining three supporting services that are included in the ESS Coding Protocol; *sedimentary cycling (A2)*, *primary production (A4)* and *soil formation (A7)*, were not addressed at all. One plan, *RP 1973*, did not address any supporting services, except indirectly biodiversity.

The first formulations of water cycling were made in RP 1936, where it was regarded important to take precipitation areas into account in spatial planning:

"It is of significance, that the location of the watersheds is regarded at the settlement of land use development proposals. In societies, which fall under more than one precipitation area, essential difficulties and additional costs at the organisation of sewage systems can easily arise, in case the waste water from one particular society must be lead to more than one recipient." (RP 1936, p. 37)

In *S 1966*, considered alongside provision of fresh water and water purification, the significant role of water cycling in physical planning was further enhanced, indirectly addressing the entire regional ecosystem:

"Precipitation affects the entire biological cycle and concerning physical planning, precipitation areas must be regarded in exploitation of ground water resources and lakes for fresh water supply for the society." (S 1966, p. 155)

The water issue was further discussed in all later regional plans, mainly concerning fresh water catchment areas (see also section *4.3*), but the role of water cycling did not return until in *RUFS 2001*. Here, the regional "blue structure" was defined as a part of the greater hydrological cycle and thereby pedagogically stressing the need for inter-municipal coordination:

"The blue structure (of the region) is part of the hydrological cycle and thereby part of a larger flow which doesn't take administrative borders into account. This implies that policy measures in the surrounding world affects the possibilities of a particular municipality to manage and plan the use of its fresh water resources. Since planning for a sustainable water management must embody a drainage area, an increased inter-municipal cooperation is necessary." (RUFS 2001, p. 52)

RUFS 2010 continued the use of the umbrella term "the blue structure", water cycling was addressed deliberately and several other ESS were connected to it:

"The fresh water resources and the natural ecosystems must be preserved. Also, the citizens and tourists must continuously be able to use the water of the region for recreation. The increasing population implies a large demand both on water as a resource and on environments near water. The regional water catchments shall be preserved. Regard must be taken both to ground water incidence as to lakes, as well as to their catchment areas." (RUFS 2010, p. 131)

The context where biodiversity is framed has also developed through history. In the two first plans, it was mainly formulated as local specific descriptions of green areas as below, in *RP 1958*:

"An inner coast and archipelago belt in the eastern part of the region is dominated by leisure areas, while green area […] make up an essential part of the landscape scene southward. A coherent conservation area engrosses the entire outer archipelago belt" (RP 1958, p. 2)

In *RP 1958*, biodiversity was also considered parallel to recreation, two ESS that since then were often framed together (see also section *4.5*), for instance in *S 1966*:

"In the choice of areas for open-air life, it is important to take nature care aspects into account. However, not to the extent that civic functions lose well-situated and of other reasons valuable areas to the sparing of vulnerable flora from wasting. Such exclusive nature care should only with exception occur in a metropolitan region." (S 1966, p. 120)

In *RP 1973*, there were no considerations regarding natural values, except indirectly through one consideration regarding the "green wedges" being a part of the regional structure. In *RP 1978*, biodiversity was, as in many other plans (see also section *4.5*), regarded with pedagogic reference to the connection to culturally valuable locations and the need for preservation:

"Land with essentially valuable natural conditions, such as unusual flora and interesting fauna as well as cultural values, should be protected and managed so that their specific character is preserved." (RP 1978, p. 77)

The importance of the green space interconnectedness was indirectly discussed earlier as well, but it was not until *RP 1991* that the upholding of such ecological mechanisms started to become a more broad strategy for the maintenance of biodiversity, both concerning local areas and the region as entirety. In *RP 1991*, such measures included the establishment of a preservation zone, which is defined as a zone that consists of national interests (riksintressen)[3] for nature care, outdoor life and cultural heritage conservation; i.e. regionally important recreation and cultural areas as well as the "green belt". In *RUFS 2001* and *RUFS 2010*, there were pedagogical illustrations of core areas (see also sections *4.4* and *5*). In the latest plans, the earlier presentations of local biological values as well as the connections to recreational values were also taken up. Furthermore, long run planning was considered necessary in consensus amongst all the three latest plans, as here exemplified by *RUFS 2001*:

"A sustainable environment for life in the long run, implies a built environment which is healthy and comprises beauty and comfort values. It also implies that green structure, water resources as well as

[3] Areas of national interests (riksintressen) are geographical areas of national value for several public interests, either in means of preservation or exploitation (Boverket 2011).

nature and cultural values are protected and preserved and that biodiversity is maintained." (RUFS 2001, p. 10)

In *RUFS 2010*, biodiversity was also framed in a climate change context, suggesting that increases in temperature will lead to major changes in the regional ecosystems:

"Climate change also affects biodiversity and the natural environment, since a change in the climate affects a whole range of processes that control the structures and functions of ecosystems. […] With a drastic increase in temperature, Stockholm could already to the end of the century expect a climate comparable to that of today's Berlin, which implies a high risk for major changes in the ecosystems of the county." (RUFS 2010, p. 69)

The nutrient cycles were historically not directly addressed, except *the nitrogen cycle* and *the phosphorus cycle* in the latest plan. However, already in *S 1966*, there was a discussion about air quality regulation qualities of the green areas (see also section *4.4*) and problems with eutrophication in public bathing facilities. In *RP 1991* and *RUFS 2001*, all nutrient cycles were addressed indirectly through mentions of connected environmental problems, as here in the latter one:

"Acidification, eutrophication of water-courses, contamination of land and water through use of chemicals, poor air quality and noise in conurbation as well as competition of land are some of the most important environmental issues in the region." (RUFS 2001, p. 22)

In *RUFS 2010*, there was a wide discussion of the impact of climate change, as exemplified above, however only framing the carbon cycle through the discussion of climate regulation. As mentioned above, two of the nutrient cycles were framed directly, regarding eutrophication:

"Where agricultural land is certainly productive, the possibility to secure cycles of nutrient salts […] must be recognized." (RUFS 2010, p. 73)

Photosynthesis was framed very briefly in *RP 1991* through a consideration of the green area capacity to oxygenate the air (see quote in section *4.4*).

4.3 Appearance of provisioning services

Table 2. Direct and indirect considerations regarding provisioning services (B)

Regional plan / ESS	R 1936		R 1958		S 1966		R 1973		R 1978		R 1991		RUFS 2001		RUFS 2010	
	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*
B1 Food - Agricultural			X		X		X		X			*X*			X	
B2 Food - commercial fishing			X		X										X	
B3 Wild food					X											
B4 Water - fresh water	X		X		X		X		X		X		X		X	*X*
B5 Biochemicals and genetic resource																
B6 Timber					X		X		X						X	
B7 Biological energy sources												*X*	X		X	
Type of consideration	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*
Total	1	-	3	-	5	-	3	-	3	-	1	*2*	2	-	5	*1*

Table 2. The table content shows a summary of which provisioning services were addressed directly (**DIR**) or indirectly (*IND*) in each plan. It also shows the total number of provisioning services addressed directly or indirectly in each plan.

The addressing of provisioning services, i.e. the ESS that maintain the production of goods, has a spread out appearance through history (see *Table 2)*. *S 1966* and *RUFS 2010* considered as many as six ESS each. *Fresh water (B4)* was taken into account in all plans through history, whilst for instance *Agriculture (food) (B1)* and *Forestry (B6)* were addressed in the early plans followed by a pause of more than three decades before reappearing in *RUFS 2010*. *Biological energy soruces (B7)* was only framed in the three latest plans. Almost no provisioning services were addressed indirectly and only one, *Biochemicals and genetic resource (B5)* was entirely ignored by the regional plans.

One thoroughgoing historical pattern for the addressing of fresh water can be distinguished, namely that focus has been on lake Mälaren as the provider of fresh water. However, the discussion has historically become more nuanced, in *RP 1936*, the catchment capacity of Mälaren was considered practically without limits:

"…take water from the, as water supplier, practically undrainable lake Mälaren…" (RP 1936, p. 11)

That is a view that changed already along *RP 1958*, which, even if still framing the fresh water supply from Mälaren as almost unlimited, recognized that there should be a few reserve catchments in the region. It wasn't until *RP 1978* that other water

catchments were named parallel to Mälaren. From *RP 1991* and on, the view has remained consistent to as the following quote describes:

"Close to one and a half million people in the county receives their fresh water from Mälaren. […] Back-up capacity is mainly provided by Bornsjön and some municipal back-up water reserves". (RP 1991, p. 58)

Notable is also that provision of fresh water was often mentioned in a broader water context.

The cases of considerations regarding agriculture and forestry that appeared were with one exception parallel to each other and mainly in similar discussions of competing land uses. Only in *RP 1958*, also regarding *commercial fishing (food) (B2)*, a different discussion was dedicated to agriculture, in means of efficiency measures:

"… agriculture in the inland parts of the region […] should be accessible for a further pushed rationalisation. […] Fishing, which is an important source of livelihood in this area, alone or in combination with agriculture, has during the last 20 years by contrast to the remaining part of east coast fishing developed slightly with regard to draft volumes. A continued rationalisation of the industry and thereby a decrease of fishermen is awaited." (RP 1958, p. 29)

The latest plan, *RUFS 2010*, provided a historically typical consideration of agriculture and forestry:

"The land outside conurban areas has a versatile character and use: agriculture, forestry, recreation areas, water catchment and not at least a large spread population. […] new development should connect to present development and conurbation." (RUFS 2010, p. 125)

Biological energy resources were first indirectly framed in *RP 1991* through a discussion regarding the need for more bio-fuel in the future. In *RUFS 2001*, the future focus remained, even if it was recognized that bio-fuels account for almost ten percent of the regional energy use it was believed that the regional provision is limited:

"Bio-fuel supply is limited within the county. In the long-run, it can, together with decay products from industry and households cover a minor part of the energy demand." (RUFS 2001, p. 86)

In *RUFS 2010*, focus in the matter was on how bio-fuels can help a more environment friendly energy use development. For instance, measures for more effective use of food waste and, as here, sewage sludge was discussed:

"Investments for biogas should be promoted in connection to sewage plants as well as in waste management and farm plants." (RUFS 2010, p. 148)

4.4 Appearance of regulating services

Table 3. Direct and indirect considerations regarding regulating services (C)

Regional plan / ESS	R 1936		R 1958		S 1966		R 1973		R 1978		R 1991		RUFS 2001		RUFS 2010	
	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*
C1 Climate regulation															X	
C2 Air quality regulation					X						X				X	
C3 Water purification and waste treatment	X				X	*X*				*X*			X	*X*	X	
C4 Regulation of water flows															X	
C5 Disease regulation																
C6 Pest control																
C7 Natural hazard regulation																
C8 Erosion regulation - soil retention																
C9 Pollination		*X*		*X*		*X*					X	*X*	X	*X*	X	*X*
C10 Seed dispersal		*X*		*X*		*X*				*X*	X	*X*	X	*X*	X	
C11 Habitat connectivity		*X*		*X*						*X*	X	*X*	X	*X*	X	
C12 Disturbance regulation - noise reduction					X											
C13 Invasion resistance																
Type of consideration	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*	DIR	*IND*
Total	1	*3*	-	*3*	3	*3*	-	-	-	*3*	4	*3*	4	*4*	7	*1*

Table 3. The table content shows a summary of which regulating services were addressed directly (**DIR**) or indirectly (*IND*) of each plan. It also shows the total number of regulating services addressed directly or indirectly in each plan.

Regulating services, i.e. the ESS that regulate ecosystem processes, were addressed very seldomly through history, however with an increasing amount of considerations recently, especially in *RUFS 2010*, where six of them were addressed directly (see *Table 3*). Three of the services; *pollination (C9)*, *seed dispersal (C10)* and *habitat connectivity (C10)* were indirectly framed through discussions of green space interconnectedness from the beginning of metropolitan spatial planning in Stockholm. Five of the services from the ESS Coding Protocol; *disease regulation (C5)*, *pest control (C6)*, *natural hazard regulation (C7)*, *erosion regulation (C8)* and *invasion resistance (C13)* were never addressed. *Noise reduction (C12)* was addressed once, in *S 1966*. In *RP 1973*, no regulating services were addressed, neither directly nor indirectly.

As mentioned above and further examined in sections *4.2* and *5*, considerations regarding green space interconnectedness appeared frequently through history and thereby related ESS were framed indirectly. A historically typical formulation can be found in *RP 1936*, even if presented as an opinion of the *Swedish Society for Nature Conservation*, wherein pollination, seed dispersal and habitat connectivity were affected:

"*…the importance of, concerning separation of conservation areas, essentially in closeness to a metropolis, as far as possible must seek to preserve large, entire and coherent environments."* (RP 1936, p. 39)

Similar formulations can be found in *RP 1958*. In *S 1966*, the framing of pollination and seed dispersal was rather made due to concerns for the cultural values of allotment gardens. In *RP 1991*, those two and habitat connectivity were for the first time, even if not outspoken, directly addressed through consequent reference to dispersal corridors in the green belt and as here, regarding the "green wedges":

"The green belt of greater Stockholm consists of biological core areas within a distance of 25 kilometers from the city centre and connected to each other so that spread of species can occur between the areas. Since the green wedges are interconnected, they can recover better after disturbances. Where dispersal corridors are narrow, small additions of habitation severely affect the areas they connect." (RP 1991, p. 56)

Similar considerations regarding biodiversity and green space interconnectedness appeared in *RUFS 2001* and *RUFS 2010*. In the latest plan, policies were even more direct:

"... high level of biodiversity […], which creates conditions for reproduction and dispersal of animals and plants. […] The areas should be kept coherent and protected against fragmentation." (RUFS 2010, p. 153-154)

Air quality regulation (C2) was addressed for the first time in *S 1966* in a discussion regarding the possible regulatory facilities of green areas:

"The role of green areas as dust separator or filter is not yet fully made clear. Observations indicate that the values of green areas from a pollution point of view are mainly psychological and merely to some extent bind dust, since sulphur dioxide values hardly seem to be reduced." (S 1966, p. 159)

It was again taken up in *RP 1991*, regarding the capacities of the "green wedges":

"They cleanse and oxygenate the air." (RP 1991, p. 34)

In *RUFS 2010*, air quality regulation was framed in a "green wedges" context together with *climate regulation (C1)*, *water purification and waste treatment (C3)* as well as *regulation of water flows (C4)* and were referred to as ecosystem services:

"The wedges also have a function of infiltration, purification or regulation of surface water flows (so called ecosystem services) for air purification and for regulation of temperatures." (RUFS 2010, p. 94)

Water purification and waste treatment was also historically often addressed. In *RP 1936* for instance, the self-purification capacity of lakes was mentioned, but the importance of artificial purification before emitting contaminants was also considered:

"*… each lake or other water-course (recipient) possesses some self-purification capacity. The emitted organic contaminants are resolved and decontaminated under the influence of biochemical processes. The purification of lakes is distinctly eased if the sewage undergoes such purification that most part of the organic mud is removed prior to emission"* (RP 1936, p. 200)

This was further addressed in *S 1966*, where self-purification of lakes was considered possible if larger sewage emissions could be avoided. In *RUFS 2001*, water purification was addressed in an overview of the blue structure concerning the water quality. As mentioned above, *RUFS 2010* discussed it in terms of ecosystem services, which also was the only mention of the expression *ecosystem services* in any of the regional plans through history.

4.5 Appearance of cultural services

Only five of the cultural services, i.e. the ESS that provide humans are of significant value for social and physical well-being, were considered historically (see *Table 4*). However, two ESS, *recreation (D6)* as well as *cultural landscapes and heritage values (D2)*, were widely framed over time. *Aesthetic (D4)* values were taken up in three different plans between 1936 and 1978. *Health (D8)* was considered more recently, as well as *cultural diversity, cultural identity and social relations (D1)* in the latest plan. There were very few indirect formulations of the cultural services and three of the ones in the ESS Coding Protocol; *Sense of place (D3)*, *Inspirational (D5)* as well as *Educational and knowledge (D7)*, were not regarded at all.

Table 4. Direct and indirect considerations regarding cultural services (D)

Regional plan / ESS	R 1936		R 1958		S 1966		R 1973		R 1978		R 1991		RUFS 2001		RUFS 2010	
	DIR	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*
D1 Cultural diversity, cultural identity and social relations															X	
D2 Cultural landscapes and heritage values	X				X				X		X		X		X	
D3 Sense of place																
D4 Aesthetic	X				X	*X*			X							
D5 Inspirational																
D6 Recreation and eco-tourism	X		X	*X*	X		X		X		X		X	*X*	X	
D7 Educational and knowledge																
D8 Health					X	*X*							X		X	
Type of consideration	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*	**DIR**	*IND*
Total	3	-	1	*1*	4	*2*	1	-	3	-	2	-	3	*1*	4	-

Table 4. The table content shows a summary of which cultural services were addressed directly (**DIR**) or indirectly (*IND*) in each plan. It also shows the total number of cultural services addressed directly or indirectly in each plan.

Recreation was considered an important interest and was an argument for the preservation of green areas in the entire Stockholm Metropolitan Area in all regional plans (see also section *5*). The recreation interest was however also occasionally considered more important than the biological values (see section *4.2* for quote). In *RP 1936*, the public access to suburban excursion resorts was mentioned. Ever since, public access to green areas has been the major issue regarding the urban green space. In *RP 1958*, this was expressed was rather romantically:

"Due to the advancement of the car (culture), outdoor life has more and more developed to some sort of excursions to forest areas, bathing places or to a rural vicinity of relatively large distance from urban development. Recreation then consists of the travelling itself and the resulting experiences of the landscape, in combination with a bush-walk, bath or a moment of rest in the free." (RP 1958, p. 29)

From *RP 1978* and forward, the topic of accessibility to green areas had more focus on walking distance from the home of the citizen:

"Residing development is in the regional plan suggested to be localised and designed in such a manner that good accessibility to green areas is obtained." (RP 1978, p. 32)

Another context where recreation was addressed in almost every plan since *RP 1958* was in regard to natural values, i.e. biodiversity (see also section *4.2*). Even if some formulations in *S 1966* tended to favour recreation interest before natural care

interests, the main ambition was to combine the two. *RP 1973* was only addressing recreation in local specific context and in *RP 1978* it was clarified that significant areas for recreational and biological interests overlap, a planning variable which was further emphasized in *RP 1991* through the discussion of the so called preservation zones:

"...large areas which in the main are not affected by exploitation, ecologically sensitive areas, areas valuable with regard to their nature or cultural values, valuable recreation areas, especially close to urban development." (RP 1991, p. 32)

That view is in consensus with the view expressed in *RUFS 2001*. In *RUFS 2010,* recreation was framed in a "green wedges" context, e.g. regarding the maintenance of the green space interconnectedness and citizen accessibility to green areas (see also section *5*). Recreation was also framed in the main theme of the management of the green structure, the urban densification:

"Thanks to the stance of policy concerning densification, the result is that the citizens continue having good access to the regional green structure." (RUFS 2010, p. 189)

Furthermore, *RUFS 2010* framed recreation very pedagogically, also including the only consideration of how ecosystems help humans finding *social relations*:

"Closeness to nature is an important quality of a metropolis. Access to a varied nature, beaches and water environments stimulate physical, provides opportunities to relaxation, silence, games and nature and cultural experiences close to home. Sites for activity, open-air facilities and events in natural environments contribute to more encounters between people." (RUFS 2010, p. 101)

Cultural landscapes and heritage values was framed in almost all plans, and often in connection to biodiversity. Considerations were both general and local. The following quote is a formulation from *RP 1936*, presented as an opinion of the *Swedish Society for Nature Conservation:*

"Concerning preservation of ancient monuments the protected artefacts shall not be left alone and abrupt in an alien or cumbering environment, but rather be preserved in larger groups and contexts alongside the natural surroundings, which is required in order for it to perform in full range." (RP 1936, p. 39)

The following quote from *RP 1991* is a local description of cultural values:

"Mid and north parts of Mörkö are of national interest for cultural heritage conservation, for instance due to Hörningsholm castle and the cultivation environment of Oax." (RP 1991, p. 123)

The ESS concerning the aesthetic values of nature was addressed in three plans: *RP 1936*, *S 1966* and *RP 1978*. In the two former ones, it was framed in specific local contexts and considered as an argument for the placement of habitation, and more widely discussed in *S 1966*:

"It is obvious that different landscape types and locations provide various conditions for the creation of a beautiful city milieu. The ambition is therefore, when new areas of exploitation are considered, that not only technical and economic factors should be taken into account, but also the conditions of the areas for the development to beautiful urban passages" (S 1966, p. 41)

In the two latter ones, aesthetic values were used as an argument for land use interests, as below in *RP 1978*:

"Land that is of greater importance for the outdoor life due to nature beauty." (RP 1978, p. 78)

The health aspect in an ESS context was first addressed in *S 1966*, where it was assumed that their role as a "dust separator" are of psychological character (see quote in section *4.4*). In the two latest plans, health of the citizens was considered an important factor for the preservation of green areas, as here pronounced in *RUFS 2001*:

"Research has showed that nature is a particularly healing power against different states of stress. Measures that aim to preserve and develop the green areas of the region as well as to shield silent areas in particular increase the conditions for a good health." (RUFS 2001, p. 50)

5 Results for RQ 2: How have the "green wedges" and green space interconnectedness been historically governed for the support of ESS?

This section will present the findings for RQ 2: "How have the 'green wedges' and green space interconnectedness been historically governed for the support of ESS?" It will summarize collected key quotes regarding the "green wedges", plan after plan in chronological order. It will capture how the interconnected green space of the Stockholm region has been framed through metropolitan spatial planning, and thus, guide the discussion of how larger ecological spatial scales have been governed for the support of ESS.

5.1 Historical considerations regarding the "green wedges"

RP 1936

In *RP 1936*, there was no mention of green wedges, but a discussion about three large connected natural preserves and the possible conflict this implies, since some of them were considered very suitable for future urban development purposes. Furthermore, improvements of the infrastructure were suggested to increase the citizens' possibilities for recreational trips.

RP 1958

In *RP 1958*, they were merely described as *almost* coherent green areas in the form of wedges pointing in between the radial pattern, consisting of main communication routes and connected development, functioning as important components of the synoptic description of the Stockholm Metropolitan Area. Besides referring to one of them as an area for military training purposes, the areas were mainly discussed in terms of holding conditions for further expansion of rail bound communication in the region and enabling future exploitation interests:

"This makes it possible to place a nuclear power plant in non-habited areas but still in closeness to habitation. This does not imply the closing of open-air areas, since also the safety area is accessible for the public; only (other) development possibilities are limited." (RP 1958, p. 49)

S 1966

In *S 1966*, green areas in closeness to the metro system were considered valuable for the expansion of habitation areas, which would increase public access to green areas for recreational use. There was a general discussion about the effects that large urban green areas have on air quality:

"The role of green areas as dust separator or filter is not yet fully made clear. Observations indicate that the values of green areas from a pollution point of view are mainly psychological and merely to some extent bind dust, since sulphur dioxide values hardly seem to be reduced." (S 1966, p. 159)

Furthermore, one of the green wedges, linked with the recreation area of Rösjön, was considered to be an important resort area as well as indispensible from a nature care point of view.

RP 1973

In *RP 1973*, the only consideration about larger green areas was in the description of the regional structure, where intermediate green wedges and connective water bodies surrounds a core area.

RP 1978

In *RP 1978*, there was a consideration of large connective nature areas valuable for recreation as well as a suggestion that additional urban development should be built with better access to green areas.

RP 1991

In *RP 1991*, the expression "green wedges" was introduced, being a part of the star shaped regional structure together with water and urban development. Strategies with expanded protection of large green areas from exploitation pressure were recommended as part of the overarching goals of the entire plan. An identification of parts of the green wedges that are in need for protection was suggested. Furthermore, the functions of the green wedges were pointed out:

"They are air cleansing and oxygenate the air. They hold accessible areas for recreation. They hold areas worthy of protection for their natural and cultural values" (RP 1991, p. 34)

They were, moreover, given significant ecologically interlinking value:

"Since the green wedges are interconnected, they recover themselves better after disturbances. Where dispersal corridors are narrow, even small-scale urban development can have wide effects on the areas they link together." (RP 1991, p. 34)

As mentioned in section *4.2*, a preservation zone was suggested, partly in order to preserve the connective green wedges. Synergy effects due to conflicting policy measures were identified: weakening of connectivity, barrier effects for animals and decreased access to areas of recreational interests. Possibilities for *total* protection against additional exploitation, *very limited* development or the establishment of green corridors were discussed for different parts of specific green wedges, as exemplified here:

"To maintain the species diversity in the area, contact with the Tyresta-Åva area is required. A nature corridor needs to be established through Tyresö beach area…" (RP 1991, p. 113)

RUFS 2001

According to *RUFS 2001*, "green wedges" make up the Stockholm region together with a "strong" region core, radial urban development and an archipelago. The connective green structure with ten green wedges, interlinked by green corridors, was promoted as unique for a metropolitan region. The green wedges consist of *value cores*, which enfold several natural, cultural and social values of significance, and *wedge areas*, that connect the value cores to each other. Furthermore, so-called *weak zones* are parts that are especially sensitive to intrusion. The preservation and development conditions of the green wedges vary, since:

"Some are relatively narrow and stretch as far as to the central parts of Stockholm. Others stretch along water areas, both by Mälaren and in the archipelago. Additional large areas and include large forest- and agricultural areas." (RUFS 2001, p. 51)

The overall ambition to develop and improve planning tools was argued to motivate a closer study of the individual green wedges. Knowledge should be deepened individually concerning factors that affect their development, the function of different links and reasons for different conflicts.

RUFS 2010

In *RUFS 2010*, the green wedges were broadly addressed, e.g. as one of the three regional geographies parallel to the landscape of mid eastern Sweden and county of Stockholm. The connective structure of the green wedges, which reaches from the surrounding rural land to the city core where it connects to the urban development, was considered to be the primary quality. A significant undertaking for the development of the region green structure is to point out certain criterions in order to:

"…preserve, develop and make the green wedges accessible." (RUFS 2010, p. 7)

The focus on green wedges was slightly different in passages where

a) *only the interests of the green wedges are taken into account,* and
b) *a context where green wedges are addressed in a multi-objective context*

The two focuses will be presented below:

a) In a context only taking the interests of the green wedges into account, preservation, biological and recreational values were in focus. They were, firstly, divided into two different components; *value cores*, i.e. the most valuable parts that

are large coherent areas consisting of several coinciding values, *green linkages*, i.e. ecological bottlenecks, narrow parts of the green wedges that are determinant for the wedges to function as large green areas. Furthermore, since some of the green linkages already are weak and others not in need for immediate protection, three classes were recognized and described, based on width and pressure from surrounding urban development. If linkages were "built away" the wedge would be broken into separate parts. In general, it was recommended that barrier effects concerning humans and animals should be avoided or measured in order to enhance the green wedges as a connective space. A more concrete figure showed how a green linkage can be developed in connection to a city core, e.g. that the green wedges should be more than 500 m wide. The benefits of such measures were discussed:

"... an opportunity to experience a relatively non-disturbed diverse nature area with dispersal opportunities for several different species, and a coherent cultural landscape. Other certain qualities that should be considered are silent areas, beaches, green linkages and values that reach over municipality and county boundaries." (RUFS 2010, p. 3)

The question of managing the green wedges as entirety across municipality borders was also approached. Inter-municipal cooperation, through coordinated management measures between different actors and time perspective assessments, is considered necessary. Furthermore, legal protection of the green wedges is discussed:

"Länsstyrelsen (the County administrative board) and the municipalities have the responsibility for which areas should be given a long-term protection. […] (There) are still areas that bind the green wedges together to a connective structure, but with lacking protection" (RUFS 2010, p. 100)

Concerning Environmental Impact Assessments (EIA) in a green wedge, it was recommended that the entire wedge should be taken into account. According to *RUFS 2010*, the potential of the green wedges can be developed through deliberate metropolitan planning, development of their recreational values, increased access to them and the provision of "good information", e.g. through "green stations" in public transport, where information about appropriate walking lanes and trails can be found. It was considered that closeness to nature has great value to the citizens, not least from a public health perspective as well as for the establishment of social relations. Furthermore, the function of the green wedges as natural waste treatment plant, i.e. by improving water and air quality, is argued to have a facilitative effect on the living environment of the city. The location of and linkages between the ten green wedges of the Stockholm region were illustrated through a map. The map was complemented

through detailed descriptions of the unique natural, cultural and social values as well as present barrier effects and ecological linkages that each of the specific green wedges enfold. The descriptions were composed similar to the following one, regarding Rösjökilen:

"Rösjökilen has a varied supply of experience values, from Törnskogen's 'wilderness' to Runriket in Täby and Vallentuna. The wedge comprises many culture historical milieus with, among other things, ancient remains and an area with the highest rune stone density of Sweden. There are several lakes with rich birdlife, and well-visited skating rinks in the winter. Rösjökilen is, in conformity with Järvakilen, one of the wedges with the greatest significance for the species diversity in Stockholm's inner parts. Here are important dispersal linkages for species living in coniferous forests and broad-leaved decidous forests, not least Meaningful for the species diversity of the National Urban Park. E18 constitutes a great barrier.j" (RUFS 2010, p. 160,)

b) RUFS 2010 had an overall policy of urban densification, which claims to make an as small intrusion in the green wedges as possible. As part of the spatial orientation of Stockholm County, the first of the two guiding principles for the regional green structure was *"a dense and experience-filled city milieu with parks and green areas"*. The second is connected to the need for new transverse routes in the Stockholm region: *"a coherent green structure and transverse routes in the transport system"*, and is based on the following assumption:

"A part of the attractiveness of the region is built upon an effective transport system and an accessible identity shaping green structure that can remain attractive." (RUFS 2010, p .131)

It was pointed out that a clear protection is needed to avoid intrusion in the coherent green structure, which could be a consequence. It was however claimed that these two interests can be consistent with each other. If the weak zones of the green wedges are strengthened and if *passages* and a *good design* is realised, the impact can be minimized and, therefore, the recreational areas made more accessible.

6 Results for RQ 3: How have conditions that allow for adaptive co-management (AC-M) developed over time?

This section will present the findings for RQ 3: "How have conditions that allow for adaptive co-management (AC-M) developed over time?" The first sub-section *6.1* will present how the view on uncertainty as a precondition for spatial planning has developed in the regional plans over time. The second sub-section *6.2* will present

findings of how the regional plans historically have encouraged or facilitated the linking of actors across scales through collaborative approaches in a green space context. The results are presented through a review of collected key quotes.

6.1 Historical approach to uncertainty

The acknowledgement of uncertainty as a precondition for metropolitan spatial planning was present in almost all of the regional plans, and was often expressed through measures concerning long-time planning. However, the connection to ecological processes was less articulated. Emphasis has been on the uncertain future demographic conditions, but already in *RP 1936*, the importance of designing the regional plan to be elastic for unpredicted changes was considered, a view that was further elaborated in *RP 1958*. The plan that perhaps most ambitiously discussed uncertainty was *S 1966*, which stated that imagination and realism are equally important in metropolitan spatial planning, and indicated that time provides insights, as in the following quote:

"... the work with a regional plan must be continuous. Different investigations of fundamental character are finalised at different times and can therefore never have equal grades of contemporary accuracy. [...] It is therefore inevitable to have a constantly updated study of facts and development tendencies as well as a continuous revision of concrete plans for different parts of the region. Thus, a finalised regional plan will never exist." (S 1966, p. 10)

RP 1973 had no considerations regarding what the uncertain population growth might imply for the societal development. In the following plan, *RP 1978*, flexibility in interpreting the planning recommendations was concerned to be an important aspect while reading. In a short passage, a relational approach to space and time, however disregarding the ecological dimension, was discussed:

"The future stands unclear in essential points, e.g. concerning energy issues, economic growth, population development and employment. When the guidelines for the continued regional planning are drawn up, the tilting point must shift from mainly concerning the revision of the plan itself to increased knowledge of how different changes in planning conditions affect planning and the future of the region." (RP 1978, p. 12)

In *RP 1991*, uncertainty was acknowledged and a long-time planning period of 30 years was suggested through two scenarios guided by different rates of economic accumulation. Ecological concerns were for the first time incorporated in that context; a long-term good management of the natural resources was suggested. *RUFS 2001*

framed major uncertainties as a precondition for the regional development, which resulted in two scenarios serving as base for the metropolitan spatial planning. Also, the regional resilience was framed with a vague connection to ecosystem processes, as the following quote illustrates:

"The robustness and vulnerability of the region is required to be analysed, especially before implementation of different policy measures and projects. The aim shall be to improve the ability of the region to resist stress, such as accidents, disasters, bad weather etc." (RUFS 2001, p. 111)

RUFS 2010 embraced uncertainty through three different planning goals on three different time scales, and a continuous open evaluation of measures during the implementation period in order to avoid goal conflicts. The complexity of and the need for innovations in the metropolitan area were discussed (see quote in section *6.2*). A social-ecological approach to uncertainty was also considered, with the vision of maintaining and developing the adaptive capacity of the region, and also explicitly and briefly the adaptive capacity of the ecosystems, as in the following quote:

"If the robustness and adaptive capacity of the ecosystems and the natural environment is strengthened, animals and plants will have a better chance to adapt to new conditions." (RUFS 2010, p. 74)

6.2 Historical patterns of linking actors across scales through collaborative approaches

All regional plans recognized that coordination between municipalities is one of the main functions of the regional plan, and since *RP 1936*, it has been consistently pointed out that the policies cannot be binding for the actors regarded in the plans. In *RP 1958* for instance, coordination in management was presented as purely an issue for the municipalities, as follows:

"Realisation (of the plan) is primarily an issue for the municipalities, which have the main responsibility. […] The municipalities can solve many issues individually; others require coordination of some form. This coordination can be noncommittal, be expressed in form of bilateral and multilateral agreements or take place in the form of the municipalities federation." (RP 1958, p. 51)

However, in *RP 1958*, there was also an opening to a more wide public participation in the implementation process, as quoted below:

"The urban community and civic life are undergoing changes beyond our possibilities to affect with development regulating measures, but expressed in the concrete social structure in a way that would make a plan false and unrealistic if it didn't integrate them as parts of its content" (RP 1958, p. 32)

Also, in many of the regional plans, especially in the early ones, views of the *Swedish Society for Nature Conservation* were presented. In *RP 1973*, there were no measures concerning social networks or other measures related to AC-M. *RP 1978* continued the path of describing power as a municipal matter, and not mentioning the green structure in such contexts. Nevertheless, the plan had the first deliberate recommendation, even if somewhat unclear of who the concerned parties are, for increasing interaction and exchange of information between different actors, as in the following quote:

"Present management control measures are foremost of administrative or economic kind. In addition to that, there are possibilities to affect development through for example exchange of information and opinion between concerned parties." (RP 1978, p. 35)

In *RP 1991*, there was an emphasis on conflicts between different scales and within different scales, often expressed through reference to national interests (riksintressen) and discussions regarding a so-called preservation zone (see also section *4.2*). However, it is unclear to what extent actors dealing with ecosystems and, as the following quote illustrates, what scales and what actors were concerned, i.e. probably politicians and officials:

"A regional coordination and consensus between the responsible actors on municipal and regional scale in order to achieve a positive development and to break the unfavourable tendencies." (RP 1991, p. 8)

RUFS 2001 emphasized a wide dialogue in the metropolitan area during the implementation period. There were also recommendations regarding the improvement of planning tools regarding green areas through the development of a new type of information system based on knowledge (see also section *5.1*). One of the aims of the system was to encourage the emergence of wider social networks for a more resilient ecosystem management:

"Knowledge about the green areas of the region is needed for different purposes by different actors on regional, semi regional and municipal scale. There should be a common interest amongst these actors to develop a regional information system for the green structure. Such system can be used to describe and analyse the supply of green areas and the recreational values of the areas as well as nature and cultural values. A common information system can conduce collection of strategic knowledge and the access of the knowledge for planning on all scales." (RUFS 2001, p. 51)

In *RUFS 2010*, social capital was framed for the first time, describing trust building between individuals and groups. However, it was considered from an individual life opportunity as well as economic growth point of view, rather than concerning the allowance for building trust between actor groups and organizations in order to improve social learning in ecosystem management, illustrated by the following quote:

"Social capital is the value of the relations between individuals and groups and the trust that the citizen's feel towards each other and society in general. In the Stockholm region, social capital is high… […] Through development of the social capital, the region can create life opportunities (livschanser) for individuals, contribute value to the region and make the region more attractive for visitors and investors." (RUFS 2010, p. 104)

Collaboration between actors on different scales was also considered important, since it can bring on innovation. Both researchers and interest organizations were mentioned in such social networks of collaboration, but not actor groups, and there was no connection to ecosystem management. Emerging social relations were however framed, for instance in the following quote:

"The metropolis is changing, complex and dense. When many people live and work close to each other, formal and informal meeting places emerge. The metropolis is contact intense and is therefore a seedbed for innovations and new ideas. Metropolises are pervaded of vivacity and change..." (RUFS 2010, p. 30)

7 Discussions

The results of this thesis show that an *ecosystem services* (ESS) approach has developed in the metropolitan spatial planning strategies for Stockholm, from inadvertently addressing some ESS in the earlier plans to a greater deal of addressed ESS in the recent plans, of which many have been done so deliberately. Such development has been supported by the historically increasing attention to the *"green wedges"*. However, the regional plans have historically failed to communicate a comprehensive understanding of ESS in terms of describing why and how different ESS are dependent on each other. Furthermore, the study shows that metropolitan spatial planning has historically not facilitated conditions for the emergence of *adaptive co-management* (AC-M).

There is an increasing concern for the ability of urban ecosystems to produce ESS (Elmqvist et al. 2008). A key argument is therefore that more attention to ESS

through metropolitan spatial planning processes and more emphasis on adaptive governance strategies would be beneficial for regional *social-ecological systems* (S-ES) (Alberti et al. 2003; Borgström et al. 2006; Niemelä et al. 2010).

The first sub-section *7.1* addresses the findings for each research question. Firstly, it examines how ESS considerations have evolved, both in regard to patterns in the four ESS categories but also if there are synergies between different ESS through history. Secondly, it describes how ESS management has historically developed in relation to changed spatial awareness through the concept of "green wedges". Thirdly, it examines how conditions for the emergence of AC-M have developed historically. Sub-section *7.2* discusses the implications that the findings have on future metropolitan spatial planning in Stockholm. Finally, in sub-section *7.3* directions for future research regarding ESS governance and cross-scale interactions in metropolitan spatial planning are pointed out.

7.1 Historical development of ESS governance in the metropolitan spatial planning of Stockholm

Firstly, this thesis partly supports previous statements about ESS management (MA 2005; Elmqvist 2008) in that ESS have historically been overlooked in urban plans. The results show that many important ESS, especially several of the supporting and regulating services, have received late or no recognition at all. Still, from an early stage of metropolitan spatial planning, many ESS have been considered. Moreover, the awareness of ESS amongst metropolitan spatial planners has clearly increased and approaches to ESS management in the regional plans have grown more ambitious over time, the latest plan *RUFS 2010* being the ultimate verification of that. These findings are similar to a study of ESS considerations in metropolitan spatial plans in Melbourne, Australia (Wilkinson 2010). In addition, the concern for spatial interconnectedness of green areas and thus the positive feedback to ESS provision has historically increased in Stockholm, especially due to a wider acknowledgement of the "green wedges". Conversely, the concept of "green wedges" has been made possible through considerations of different ESS, such as biodiversity and recreation. The study also shows that metropolitan spatial planning has historically not facilitated conditions for AC-M, neither uncertainty nor any other collaborative approach with

the exception of the coordination between municipalities have had an approach that connects the social scales of management to ecological processes.

Research question 1: "How have ecosystem services (ESS) been addressed over time?

The discussion regarding RQ 1 is divided into five sub-sections; the first discusses prevalence of ESS consideration in general and the following four discuss main findings regarding the four respective categories of ESS; supporting services, provisioning services, regulating services and cultural services.

Increasing policy intent regarding ESS

As stated above, this study shows that an ESS approach has evolved in metropolitan spatial planning in Stockholm. The first plan included several important formulations beneficial for the maintenance of ESS and seven ESS were directly considered, but in comparison, the latest plan *RUFS 2010* held as many as 21 ESS directly addressed through written policy. Furthermore, changes in the amount of ESS directly addressed have historically coincided with changes in the amounts of ESS indirectly affected by policies. One exception is *RUFS 2010*, where the ratio is 21 to 6. Even though formulations only indirectly address ESS, such formulations most likely imply a higher chance for beneficial effects on ESS if the policies are implemented. However, regarding *RUFS 2010*, the relatively lower amount of indirectly addressed ESS compared to ESS directly addressed does however not necessarily have negative impact on eventual implementation, since the all indirectly addressed ESS except one are covered by thorough direct considerations. Moreover, it seems as if ecosystem management started to receive more substantive attention in metropolitan spatial planning in Stockholm in 1990's, i.e. after the *Brundtland report* (WCED 1987), and has continued to be an important strategy in regional plans. It is obvious that understanding regarding the services that are provided by the metropolitan green structure has increased during the last 75 years of metropolitan spatial planning in Stockholm and policy makers of the latest plan, *RUFS 2010*, have made this awareness to more systematic policy intent for the benefit of ESS, with less indirect formulations completed by a higher amount of ESS considered directly.

Even though this study implies that awareness of ESS has increased historically and peaking with the latest plan, the analysis also show that there has not been a successive increase of the amount of ESS considered from one plan to the next one;

the prevalence has rather jumped up and down until recently. For instance, the third and fourth plans of this study, *S 1966* and *RP 1973*, have respectively the third highest and the lowest amount of ESS directly addressed of all eight regional plans. This finding implies that there has been awareness that has not always been converted into policies. Furthermore, given the historical tendency of uneven development in ESS considerations, it seems as if decision-makers have not continued where the former plan passes on. In that sense, the ESS governance of the regional plans has been a product of contemporary values instead of continuity in management principles. This also makes it difficult to certainly distinguish the governance of each specific ESS, i.e. they are focused randomly. Thus, in terms of ESS in a historical sense, the larger temporal scale is not attended to sufficiently, which in the long run can have consequences for the interactions between ecological spatial and temporal scales. The use of the ESS Coding Protocol enlightens the presumable shortcomings of the absence of a continuous framework that helps determine what guidelines are desirable.

In terms of the four ESS categories, it is difficult to point out which of the categories have historically been more in focus than others. The different categories as tabled in the ESS Coding Protocol include different numbers of ESS, which makes such comparison difficult. However, it can for instance be concluded that supporting services and regulating services has not been addressed at all whereas others have sort of come in the backdoor, having been disregarded in the beginning of metropolitan spatial planning and grown to be directly addressed in later plans. Provisioning services, of which the provision of fresh water dominate historically, tend to have historically been framed individually and cultural services have, in terms of recreational needs of the citizens, been framed widely. Considering the recent scientific classification of the two groups of categories as respectively intermediary services and final services (Mäler et al. 2008), this tendency makes sense. Furthermore, the findings enlighten the notion in Raudsepp-Hearne et al (2010) that there is insufficient regard to so called ESS bundles in resource management in general. Some ESS have historically been framed parallel to each other, however with many ESS lacking such bonds to other important ESS in the same landscape or social context. The lack of such linkages also indicates that the linkages between the different ESS and other constituents of human well-being have not been taken into

account as effectively as they could have been, i.e. as recommended by the MA (2005).

Biodiversity and water cycling - historically prevalent supporting services

Supporting services are especially important to maintain since they are necessary for the upholding of all other ESS, and their impact on human well-being is often indirect and changes occur over a long period of time (MA 2005). This thesis shows that the regional plans of the Stockholm Metropolitan Area have historically been more attention to some supporting services and less or no attention at all to others.

A high level of biodiversity is desirable for the resilience of an ecosystem (Folke et al. 2004). In fact, the establishment of the term *ecosystem services* (ESS) is directly connected to the worldwide concern among scholars for biodiversity loss and ecosystem degradation. Through helping individuals and institutions understand the value of nature, ESS is aimed to make conservation biology attractive, commonplace and easier to make instrumental (Daily et al 2009). Biodiversity has historically been an important feature in metropolitan spatial planning in Stockholm. Nature concern seems to always have been good at one aspect of preservation, namely in terms of individual local contexts of nature values. Moreover, large interconnected green space and related regulating services that are relevant for the maintenance of biodiversity have become increasingly regarded. Such considerations have been helpful for the emergence of the concept of "green wedges" and thereby presumably also for relatively high levels of biodiversity. This will be further discussed later. Furthermore, the intrinsic values of biodiversity have not been clearly described by regional plans historically.

Water management is a topic thoroughly considered over time, mostly regarding fresh water provision and to some extent water purification. However, the entire hydrological cycle has been addressed less, even if more deliberately in the latest plans. Water cycling is one of the most crucial supporting services for all other ESS and is required for all life on Earth. Moreover, cultivated and urban systems must serve water for around five billion people but generate respectively 16% and 0,2% of the global fresh water runoff (MA 2005). Therefore, it is of great significance to frame the entire cycle in a fresh water context in metropolitan spatial planning. In *RUFS 2010* this is done more adequately than before, through framing the

hydrological cycle as important for "the blue structure", by making clear that the fresh water supply of the region is dependant on groundwater resources and the catchment areas of lakes as well as through concerns for the risks for flooding due to future climate change.

The remaining supporting services, with the exception of some considerations regarding nutrient cycles through related environmental problems, have hardly been addressed at all, which is noteworthy since the maintenance of these services is necessary for the upholding of all other ESS and should therefore be taken into account by decision-makers (MA 2005). In *RUFS 2010*, the nitrogen cycle and the phosphorus cycle are briefly but anyhow concretely framed, with recommendations of what should be done in agricultural land use in order to address this problem.

Provisioning services is dominated by fresh water and in general mostly framed in contexts isolated from other ESS

As population growth has increased during the last century, the needs for water, food and timber as well as the subsequent unsustainable use of these provisioning services have increased rapidly (MA 2005). This thesis shows that many provisioning services have historically been taken into account by metropolitan spatial planning in Stockholm, however also in many cases in contexts isolated from other ESS.

Fresh water provision is perhaps the most important provisioning service for a large urban population and an issue of certain importance in management (MA 2005), which explains why it is directly addressed in all regional plans of the Stockholm Metropolitan Area. Lake Mälaren is considered to be the self-evident provider of fresh water for the inhabitants of Stockholm County and the formulations through history differ marginally, even if alternative reserves and the dependence of water cycling has been increasingly considered over time. That is of great significance, especially due to risks for future salt-water intrusion in lake Mälaren as a consequence of eventual climate change. In hundred years, in a worst-case scenario, the sea could rise up to a level that would transform Mälaren into an inlet of the Baltic Sea. The magnitude by which such salt-water intrusion could affect future fresh water provision can be illustrated by that the population growth of Stockholm County is estimated to be between 200.000 and 1.5 million only in the next thirty years (Klimat och sårbarhetsutredningen 2006; TMR – SLL 2011; Länsstyrelserna 2011).

Concerning some of the other provisioning services, a different pattern arises. In resource management literature, food is considered one of the ESS that humans have historically prioritized, which has lead to degradation of particularly supporting and regulating services (MA 2005; Raudsepp-Hearne et al. 2010). In the contexts where important provisioning services such as agriculture and forestry are addressed in the regional plans of the Stockholm Metropolitan Area, they tend to be viewed upon as superior to preservation interests, alternatively for parallel land use with recreation. Likewise, the framing of biological energy resources in recent plans is discussed concerning the possibilities for provision itself. They are in a way separated from most other ESS and not directly considered as part of the green structure as an entirety. In other words, the regional plans have historically recognized many provisioning services, but failed to recognize possible trade-offs (Raudsepp-Hearne et al. 2010) between them and other ESS. In this sense, the concerned provisioning services are taken for granted.

Regulating services historically overlooked except for the ESS connected to green space interconnectedness and ecosystem renewal

Several of the important ESS of the Stockholm Metropolitan Area are regulating services, such as climate regulation, air quality regulation, seed dispersal and pollination (Elmqvist et al 2004; Mäler et al. 2008). In the regional plans most of these services are historically overlooked. In the latest plan, *RUFS 2010*, some of these services, climate regulation, air quality regulation as well as water purification and waste treatment, are however actually framed as *ecosystem services*.

Given the increasing spatial heterogeneity of a typical urban landscape (e.g. Pickett et al. 2001), seed dispersal, pollination as well as habitat connectivity are perhaps the most important ESS to maintain in urban S-ES (Ernstson et al. 2010a) as they are they are the main factor for maintaining high levels of biodiversity in urban ecosystems (Alberti 2005). Thus, framing biodiversity alone, e.g. through local preservation measures or mentioning of high biological values, as especially the earlier regional plans often did, is insufficient for the maintenance of ESS production in a metropolitan area. Sörlin (1998) states that dividing natural areas into “higher valued” and “lower valued” is a social fabrication and concept, i.e. that green space has no actual internal hierarchy. If a “higher valued” area is protected, it does not automatically mean that the spatial and functional interconnectedness of the regional

ecosystems will benefit from that. It is emphasized that such areas, as when developed space is concerned, should be planned and managed taking local land use history and surrounding landscape conditions into account (Borgström et al. 2011). Nevertheless, Ernstson and Sörlin (2009) recognizes that *"concepts like […] `dispersal corridors', and `core and buffer areas' have been picked up by a concerned wider public and used for arguing for the preservation of biodiversity and red-listed species"* (Ernstson and Sörlin 2009, p. 1468). Metropolitan spatial planning in Stockholm has increasingly and in different ways developed such framing, especially in the latest regional plans. The existing ecological interconnectedness, in this case primarily through the reference to "green wedges" (see further discussion below), has become used as a planning tool for green space parallel to pedagogical instructions of why and how they must be maintained. Such development is perhaps the most obvious verification of increased policy intent regarding ESS in metropolitan spatial planning and ultimately one the most important basis for the future production of other ESS through metropolitan spatial planning.

Due to recent attention to the uncertain future of the climate change (e.g. IPCC 2007), it would have been surprising if climate regulation had not been addressed at all. And in fact, it has sort of come in the backdoor through indirect addressing of the carbon cycle in a climate change-context in the recent plans. Many of the considerations regarding carbon dioxide cannot be applied to the green space ability of climate regulation. Nevertheless, even if the connection to relevant ESS has been weak, this does not necessarily imply that the regional plans have overlooked the issue of changing climatic conditions in the Stockholm Metropolitan Area. For instance, the formulation *"a high risk for major changes in the ecosystems of the county (due to climate change)"* (RUFS 2010, p. 69) is an obvious indicator of the awareness of the critical situation. Moreover, moving on from the issue of climate change, several important regulating services have not been considered at all. The suddenly increased prevalence in the most recent plan and the contextual reference to ecosystem services however indicates awareness amongst the policy makers.

Recreation represents the cultural services and helps biodiversity conservation

The MA (2005) states that *"…human cultures, knowledge systems, religions, social interactions, and amenity services have been influenced and shaped by the nature of ecosystems"* (MA 2005, p. 120); i.e. nature provides us with cultural services. The regional plans of the Stockholm Metropolitan Area appears to have very sporadic and vague formulations

regarding cultural services in general over time, with most direct considerations in *RP 1966* and *RUFS 2010*. Many of the cultural services in the ESS Coding Protocol are however difficult to frame in a regional plan and perhaps also hard to recognize in policies. Cultural landscapes and heritage values has historically been framed in almost every regional plan, though in very short formulations. It is an important ESS, since maintenance of cultural artifacts and landscapes often helps maintain local levels of biodiversity as the surrounding area is protected and as the floral and faunal composition often is a part of the cultural landscape (Emanuelsson 2009) and many of the regional plans have used this perception. Nevertheless, there is one greater exception amongst the cultural services that has been widely framed, namely recreation, which has also been ascertained to be one of the most important ESS of the Stockholm Metropolitan Area (Elmqvist et al. 2004). One possible explanation to the low prevalence of other cultural services could possibly be that the word *recreation* to a certain extent is understood and used as an umbrella term for many cultural services in some regional plans. That is, it is assumable that recreation in many people's eyes means becoming intrigued by the aesthetic beauty of nature, *or* gaining mental well-being *or* accumulating knowledge of their surrounding, *or* establishing social relations *or* all of these aspects. The following quote in *RUFS 2010* indicates that such reasoning concerning human closeness to nature is perceived by policy makers: *"Closeness to nature is an important quality of a metropolis. Access to a varied nature, beaches and water environments stimulate physical, provides opportunities to relaxation, silence, games and nature and cultural experiences close to home. Sites for activity, open-air facilities and events in natural environments contribute to more encounters between people."* (RUFS 2010, p. 101). In other words, even if the cultural services as a category appear to have historically had little attention, they actually might have had the most attention in comparison to the other categories of ESS, even if that comparison that is difficult to make due to earlier stated reasons as well. Nevertheless, they have the most direct emotional impact on humans, which has presumably been intentionally taken up by policy makers. As literature has pointed out (Pyle 1993; MA 2005; Miller 2005), the urban citizens' need for access to green space has proven to indirectly enhance public support for ecosystem governance, and no less in the Stockholm Metropolitan Area. The regional plans historically framing recreation in a context of larger scale green area preservation has probably to a certain extent lead to the maintenance of green space interconnectedness and thus biodiversity and ESS.

Research question 2: "How have the "green wedges" and green space interconnectedness been historically governed for the support of ESS?"

The concept of the "green wedges" support several important ESS

As pointed out earlier, the ecological values of the "green wedges" in general and the National Urban Park of Stockholm in particular have in the last decade been popular subject of research (e.g. Elmqvist et al 2004, Colding et al 2006; Ernstson and Sörlin 2009). It has been recognized that they are shrinking in size as well as decreasing in ecological connectivity (Colding et al. 2006). It is therefore rather surprising that the latest regional plan *RUFS 2010* state that the connective green structure of the Stockholm Metropolitan Area is of primary quality. Nevertheless, recommendations advocating that "green wedges" should be taken into account at a wider scale both in local and regional spatial planning (e.g. Colding et al 2006) has assumingly been heard by policy makers. This study shows that the consideration of the" green wedges" has historically increased in the regional plans. From an early recognition of wedge-like green areas important for recreational needs and as a part of the regional structure, the green wedges have recently been noted as holders of important ecological functions that are worthy of protection due to their crucial significance for the green space interconnectedness. Without knowing the extent to which the recommendations in the regional plans affect actual management, it can be assumed that such historical concerns have enabled the emergence of the expression "green wedges", as elaborated earlier. Furthermore, it must be pointed out that the pedagogic theoretical recommendations in the latest two plans are ambitious, in the latter more detailed than in the former. As is the call for wider and more specific scientific understanding in *RUFS 2001* as well as the detailed local descriptions of all "green wedges", the consistence regarding the citizen's access to green areas, recommendations regarding inter-municipal management and framing them in an Environmental Impact Assessment context in *RUFS 2010*. In this sense, the governance of the "green wedges" through the regional plans might even support several ESS that regional plans do not address. There are however two inhibiting variables, namely that the latest regional plan does not accept the scientifically established degradation of the "green wedges" as a precondition for their maintenance as well as the vagueness regarding the priority of land use interests; i.e. between green space preservation and aiming for addition in the infrastructural net might overlook

the broader benefit of the "green wedges" and view upon green space interconnectedness as secondary. Nevertheless, the thorough examination of how important the "green wedges" are for the regional ecosystems as well as of what kind of action is needed to increase their functionality is promising for the future governance of green space and regional ESS.

Research question 3: "How have conditions that allow for adaptive co-management (AC-M) developed over time?"

AC-M is historically not sufficiently addressed

AC-M is a way of realizing adaptive governance, which is relatively recent mode of governance that has emerged through resilience thinking. AC-M is considered to be an important feature of ESS governance (Berkes et al. 2003; Folke et al. 2005). The late scientific emergence of such management principles is probably one of the main and less-surprising reasons to why AC-M has not been allowed for in the metropolitan spatial planning in Stockholm over time. Nevertheless, one of the key components of AC-M is to embrace uncertainty (Folke et al. 2005). Daily et al. (2009) argues that it is essential that decision-makers begin to address planning issues that involves uncertainty aspects with more widely evaluated scenarios of the future provision of ESS. Whilst uncertainty associated with the urban condition, mostly in terms of demographic change, has been acknowledged throughout the era of metropolitan spatial planning in Stockholm, the connection to the temporal scales of ecological processes has been less present in the plans. *RP 1991* and *RUFS 2001* had vague connections to social-ecological uncertainty. In *RUFS 2010* however, adaptive capacity and robustness of ecosystems was framed, which indicates that the policy makers were acquainted with the terminology of social-ecological resilience. This is a step in the right direction, yet insufficient if framed alone, since it is hard for non-acquainted practitioners to interpret such formulations into practical measures. One of the main features of AC-M is social learning, which embraces uncertainty through collective learning-by doing processes (e.g. Folke et al. 2005). This requires social networks, which are particularly crucial in metropolitan S-ES and desirably ranging from local to regional scale (Ernstson et al. 2010a). Earlier analyses made in the Stockholm Metropolitan Area have shown that local actor groups are not linked to spatial scales of ecosystems and that they are not sufficiently framed on regional level (e.g. Borgström et al. 2006). By examining the historical approach to governance, this

study has found very few measures that enhance social capital and enable collaborative approaches through social networks in a social-ecological context. Historically, the regional plans have regarded inter-municipal coordination with some theoretical but not deliberately guiding connections to the preservation of natural values. One formulation in the second latest plan *RUFS 2001* addresses the need for social networks and a new knowledge system where regional actors on all levels interact. It is difficult to know if such well-willing but timid measure can help the emerge of larger social networks with scale crossing brokers and shared power for a functioning cross-scale interaction in the Stockholm Metropolitan Area. That is, especially since the only considerations regarding social capital and actor collaboration in the following and latest plan, *RUFS 2010*, were aiming for more innovation in undefined development contexts and will thus hardly be connected to the framing of "adaptive capacity". These findings indicate that there is some awareness of what social processes need in order to work properly, but these processes have not been connected to governance of ecological processes. The regional plans have not facilitated enabling conditions for the emergence of AC-M historically.

7.2 Implications for metropolitan spatial planning

The findings presented above lead to the question of how metropolitan spatial planning can be developed for a better governance of ESS, in Stockholm in particular. As earlier elaborated, metropolitan spatial planning in Stockholm has taken an ESS approach in the sense that many important ESS and some specifically significant ESS for the governance of urban systems have received increased attention not least in the latest regional plans. Such development is welcomed to continue. Furthermore, the pedagogical approach to the "green wedges" in the latest plan is good whereas the attention to regional ecological spatial scales could be improved with adjustments of the vagueness in the overall strategy of *RUFS 2010*. However, the temporal scales of ESS governance need more attention in terms of continuously adapting policies to changes in ecosystems and by reassessing the meanings of earlier plans. Furthermore, in order to extend the existing ESS approach and make it more comprehensive, further pedagogical attention needs to be directed to supporting and regulating services in general. Finally, the inclusion of certain AC-M principles in metropolitan

spatial planning should be tested. In other words, improvements can be made, especially in order to increase the understanding of cross-scale interactions in the metropolitan social-ecological governance. More specific discussions regarding these implications follow below.

Development of an adaptive ESS framework for future metropolitan spatial planning in Stockholm

This thesis has used the ESS Coding Protocol as an instrument for the analysis of ESS considerations in metropolitan spatial planning, but has in a way also tested its capacity to quantify ESS in management. It has proven to be useful in the analysis. However, it can also help further improve governance of regional ESS. One issue that the ESS Coding Protocol enlightens is the risk for temporal mismatches in metropolitan spatial planning conduced by the historically random focus on ESS as consequence of contemporary values. In order to better manage temporal scales of ecological processes and thus ESS governance, which is desirable despite recent improvements in that sense, one suggestion is to develop a framework that considers such complex of problems, i.e. a continuous adaptive ESS framework. Instead of creating a new framework for each event of a new regional plan, which makes it difficult to perceive and react on what has happened over time, such framework would continuously regard and adapt to changes in the regional ecosystems as well as to earlier decision-making. It can emanate from the ESS Coding Protocol (created for this thesis), but have a more comprehensible match for the specific conditions of ESS of the Stockholm Metropolitan Area and include input mechanisms that facilitate adaption to earlier decisions. This would help metropolitan spatial planning approach the city as a CAS and the relations between space and time as well as ultimately improve governance of cross-scale interactions. A framework taking such social-ecological contextual individuality into account would furthermore help the analysis of earlier decision-making, i.e. in say 40 years, it would provide an ESS analysis of the type in this thesis with substantial insights.

Development of a pedagogic approach in metropolitan spatial planning to the significance of ESS for the functioning of the entire urban system

The analysis shows that provisioning services and cultural services have been addressed in a manner that confirms with the view described in Mäler et al. (2008), namely that they could be viewed upon as *final services*. These services affect human-

well being directly and are sometimes framed as goods from nature and sometimes taken for granted. Furthermore, some of the supporting and regulating services have also occasionally been framed very pedagogically, especially through considerations regarding green space interconnectedness framed by the "green wedges" concept. However, many of these services have been disregarded or addressed sporadically in passing. This is probably due to their character of indirect impact on human well-being. The MA (2005) suggests that indirect linkages between ESS and human well-being must be mediated by socioeconomic factors contextually, which metropolitan spatial planning for the Stockholm Metropolitan Area is a good example of. One way of addressing this is to have the concept of ESS bundles (Raudsepp-Hearne et al. 2010) in mind, i.e. to deliberately and more clearly frame ESS that appear in the same landscapes or social contexts. A more synoptic and probably more effective way to enlighten the vital importance of planning for ESS in a metropolitan area is to develop a pedagogic approach with emphasis on the *intermediary services* (Mäler et al. 2008), i.e. to comprehensively group supporting services and regulating services together, the ESS that affect humans only indirectly. This can for instance be made through figures with feedback illustrations and arrows to emphasize how the ecological domains of the urban landscape affect human well-being, preferably simplified in an overview of the main strategies of the regional (development) plan and more detailed in a green structure section. Such framing can educate and increase knowledge amongst practitioners of the importance of ESS for human well-being and create a larger understanding of the cross-scale interactions of the social-ecological urban system. Furthermore, it is a consciousness-rising measure regarding the need for high levels of urban biodiversity and spatial interconnectedness. With such addition, the present ESS approach would be extended to be much more sufficient in guiding practitioners and planners on more local scales in a way that benefits the future provision of ESS.

Metropolitan spatial planning in Stockholm can help encourage AC-M through trust building (social capital)

The findings show that AC-M is not framed sufficiently in the regional plans of the Stockholm Metropolitan Area. Armitage et al. (2009) points out that further research regarding the best way of framing AC-M in policies must be conducted, partly due to the individuality of different social-ecological contexts. Given the slow development

process of co-management, there is always a risk that policy makers have low patience regarding uncertain outcomes and the possibly high transaction costs that AC-M can imply (Ruitenbeck and Cartier 2001; Armitage et al. 2009). In a metropolitan spatial planning context it is of course also difficult to identify the best way of encouraging AC-M, which is confirmed through the study conducted for this thesis. One characteristic in favour of the urban system is nevertheless their ability to create innovation and a high density and diversity of actors that provide a unique possibility for social networks to emerge in urban S-ES (Bettencourt et al. 2007; Arbesman et al. 2009; Ernstson et al. 2010b). However, the legislative context of the regional plan of Stockholm implies limited decisive power. This can be negative in a metropolitan spatial planning context, since no other actors have the absolute obligation to carry out the meanings of the policies. However, for the same reason there are hypothetically opportunities to increase social capital and to build trust between the regional plan and other scales of management, since the role of power is not as static as in institutions that have an absolute decisive power. Therefore, it is of certain significance to encourage testing of AC-M and to seek to encourage social networks to emerge through metropolitan spatial planning. An example will be further elaborated in the next section.

City scale networks can be framed by metropolitan spatial planning in order to allow for the emergence of regional AC-M

Ernstson et al. (2010a) suggests that the provision of ESS should be a priority in adaptive governance and identifies that actors desirable for regional green infrastructure scale governance in Stockholm already exist. This thesis shows that metropolitan spatial planning has evolved historically from focusing on recreational and certain local biodiversity values to a larger emphasis on landscape ecological processes, such as seed dispersal and pollination, that support ecosystem renewal and thereby biodiversity (Alberti 2005). The preservation of interconnected green space has become a very important ingredient in the regional plans. Many policy meanings have helped increase awareness of its significance as a regional spatial matter, for instance through the following types of considerations: the traditional belief in recreation as inherent to human well-being, early considerations of the aesthetic beauty of nature, opinions of the *Swedish Society of Nature Conservation*, the evolution of the term “green wedges” and their meaning for the region as well as

specific preservation-"worthy" biological values. Furthermore, these concerns have all grown mutually and have increasingly become addressed in bundles while becoming more difficult to separate contextually. In a way, metropolitan spatial planning has adapted itself to increased knowledge and is an important actor in the regional social network. However, as pointed out earlier, the regional plans of Stockholm have failed to help the emergence of AC-M. Ernstson et al. (2010a) identifies that there is a presence of homogenous social networks in Stockholm that occasionally span across the region. Nevertheless, they do not bridge over to other actor groups, *"e.g. cemetery managers do not communicate with allotment gardeners"* (Ernstson et al. 2010a, p. 42). In other words, there is a lack of city scale green networks in the social-ecological governance of the Stockholm Metropolitan Area, where scale-crossing brokers can focus on coordination of networking between multiple ecological scales and, thus, help the alignment of them (Ernstson et al. 2010a). This thesis has shown that there is a historical coordination between municipalities in the regional plans as well as that recent policy holds awareness regarding the advantages of actor cooperation, even though without addressing ecological processes in the latter type of context. Furthermore, it seems as if decision-makers responsible for the green structure really do possess sufficient knowledge about green space interconnectedness; recent plans provide significant and pedagogical information on landscape ecological functions and how those functions can be maintained, which is helpful for more local scales of management. The emergence of AC-M is difficult to frame in policies; there is no blueprint for co-management design (Ruitenbeck and Cartier 2001; Ostrom 2007), and little analysis has been made regarding how it can be linked in policies (Armitage et al. 2009). There is furthermore little research on who or what the scale-crossing brokers are (Ernstson et al. 2010a). Metropolitan spatial planning in Stockholm could address city scale networks and deliberately stress the need for actors or institutions that can act as scale-crossing brokers. Combining that with the development of an adaptive ESS framework for metropolitan spatial planning, as suggested above, can help future regional (development) plans to facilitate more resilient social networks and allow for the possible emergence of a regional scale AC-M that that better deals with cross-scale interactions. Learning-by doing and thereby also testing new planning principles is an important feature of AC-M and is needed in the process of making urban S-ES more resilient (Olsson et al. 2004; Armitage et al. 2009).

7.3 Future research directions

Colding et al. (2006) states that the regional green structure in Stockholm is shrinking and causing loss of ESS, i.e. despite increased deliberate formulations regarding ESS in recent regional plans, as this thesis has shown. In order to fully understand how metropolitan spatial planning should best deal with cross-scale interactions and ESS management, there is a need for further analyses of the documents used for this thesis, wider comparisons with other levels of decision-making and management as well as deeper comparisons with metropolitan spatial planning around the world. The following suggestions can all provide valuable insights to the study of cross-scale interactions (e.g. Borgström et al. 2006; Cumming et al. 2006) and the role of ESS as a concept in governance of urban S-ES (e.g. MA 2005; Niemelä et al. 2010), in particular for metropolitan spatial planning:

- Further analyses of the documents used in this study, i.e. the full range of regional plans of Stockholm, could include research of how temporal scales of social and ecological processes has been dealt with, both regarding policy meanings and the possible temporal mismatches that the timeframes between the different region plans can imply.
- If AC-M principles will become tested through written policies in metropolitan spatial planning to a wider extent in the future, for instance in such manner as suggested in this thesis, research should be conducted parallel to such testing. It would hopefully provide significant insights to scientific gaps regarding self-organization of AC-M (Armitage et al. 2009). This would, furthermore, help improve the dynamics between decision-making and research.
- Other important aspects that this study has not fully taken into account are the ambiguity of some measures and possible dichotomies or synergies between policies aimed for ecosystem management as well as deliberate strategies for other societal orientations, such as the quest for economic growth and densification of habitation. Many of such orientations are driven by innovation and are connected to that in the regional plans, and as Ernstson et al. (2010b) recognizes, urban innovation in terms of social networks that lead to new sustainable notions is one of the main sources of urban ecosystem maintenance. Therefore, such analysis can complete the findings of this thesis

and provide a broader social-ecological understanding of metropolitan spatial planning in Stockholm.

- Analyses that enhance the understanding of metropolitan spatial planning as an actor is also needed. This thesis identifies many question-marks regarding how measures has been perceived by management on lower scales. An analysis that explores this further could be made through triangulation of findings as above with relevant historical land-use analyses and eventual quantitative interviews with related actors and managers. Such quantitative interviews can seem to be hopeless since they only can be done for recent regional plans, conducting them now can however also help historical analyses of this kind in the future. If, as suggested above regarding implications for metropolitan spatial planning, an adaptive ESS framework specialized for the Stockholm Metropolitan Area is developed, long-term future research regarding the role of the regional plans will also be extensively facilitated.
- At last, a more nuanced view of ESS governance through metropolitan spatial planning requires that similar studies using analytical tools inspired by the ESS Coding Protocol are conducted in other metropolitan areas globally. For instance, the findings of this thesis will be published alongside with the findings of Wilkinson (2010) regarding metropolitan spatial planning in Melbourne, Australia.

8 Conclusions

The aim of this thesis was to examine how *ecosystem services* (ESS) have historically been governed through the regional plans of the Stockholm Metropolitan Area. The study has shown that an ESS approach has developed over time, with an increasing amount of policy considerations where ESS have been deliberately addressed. The "green wedges" of the Stockholm Metropolitan Area have received increased attention, become a valuable planning tool for the regionally interconnected green space and, thus, helped improve regional governance of ESS. Even though improvements have been made, many ESS have had late or no attention at all and the linkages between different ESS have been weakly considered. Finally, the study shows that the regional plans have not facilitated conditions for the emergence of *adaptive co-management* (AC-M) in the Stockholm Metropolitan Area.

This kind of historical analysis is important to conduct, since it clarifies how the metropolitan spatial planning intent has or has not dealt with ESS, which is significant for urban social-ecological research. It is a critical starting point in guiding where future policy improvements and research efforts regarding ESS and AC-M aspects in metropolitan spatial planning can be directed. Subsequently, it can increase the understanding of cross-scale interactions in metropolitan areas and lead towards a more adaptive governance of urban ESS.

There has been a great loss of green areas, ecosystems and ESS in the Stockholm Metropolitan Area during the last decades (Elmqvist et al 2004; Colding et al. 2006). Nevertheless, this thesis confirms that metropolitan spatial planning in Stockholm has, from an early stage on, generally recognized the benefits and services that the ecosystems provide humans with. In addition, the level of considerations regarding green space interconnectedness has lately increased seemingly alongside increases in scientific knowledge, not least through the concept of the "green wedges". In this respect, the regional plans have come closer to an ESS approach without calling it that. This supports similar findings for Melbourne, Australia (Wilkinson 2010). Wilkinson (2010) argues that this finding urges caution, as to the ESS approach per se being a panacea for improved environmental management in metropolitan areas. The findings from Stockholm support the importance of an ESS approach in metropolitan spatial planning. However, as mentioned above, many ESS have had late or no attention at all in the region plans of the Stockholm Metropolitan Area, which is especially pronounced amongst the intermediary services (Mäler et al. 2008), i.e. the ESS that only indirectly affect human well-being. Also, the linkages between the different ESS and their implications for human well-being have not been fully considered historically. This calls for further improvements of the metropolitan spatial planning strategies for Stockholm, such as pedagogically describing the intermediary services, the connections between different ESS as well as between ESS, urban functions and human well-being. Furthermore, the findings of this thesis call for the development of new adaptive ESS tools. One suggestion that is discussed above is to design an adaptive ESS framework inspired by the ESS Coding Protocol, but that also takes into account and successively adapts to local and regional ecosystem changes as well as earlier decision-making. Such tool would, in addition to being scientifically valuable, have the purpose of guiding future decision-makers in metropolitan spatial

planning in preventing temporal mismatches in the regional ESS management.

Whereas a good deal of progress has been made on adding ecological scales into metropolitan spatial planning, i.e. through an increase of considerations regarding ESS, the recognition of the role of social processes in ESS governance has been less pronounced. Ostrom (2007) states that both researchers and decision-makers that consider outcomes in S-ES must recognize contextual variability both in the social and ecological domains. This thesis supports Borgström et al. (2006) in that an adaptive governance approach is yet to be included in metropolitan spatial planning for the improvement of regional green space governance. The regional plans of Stockholm must test new strategies that can help the emergence of more AC-M in the region. In the discussions above, a suggestion is to address city scale networks in regional plans and to deliberately stress the need for scale-crossing brokers. This is only one way in which metropolitan spatial planning could facilitate more resilient social networks and the possible emergence of a regionally spanning AC-M. Through the endeavour of creating enabling conditions for AC-M, the regional plans can help avoiding mismatches between scales of ecosystem processes on one hand, and social scales of ESS governance on the other hand. This is desirable for the future provision of ESS in the Stockholm Metropolitan Area.

Metropolitan spatial planning in Stockholm should further develop the ESS approach as depicted in the latest plan, *RUFS 2010*, supported by the "green wedges" concept. There should be more emphasis on communicating a more pedagogical and comprehensive view of how different ESS are connected to each other, the functioning of the city and the well-being of the citizens as well as on creating an adaptive ESS framework for future planning and, finally, on encouraging adaptive governance strategies and facilitating conditions for the emergence of AC-M in the region. These are important implications for how ESS governance through regional plans can help improve social-ecological resilience in the Stockholm Metropolitan Area as well as advance the understanding of cross-scale interactions.

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Appendices

Appendix 2 ESS Coding Protocol

Supporting services (A)

SD	ESS	NOTES	CODING DIR	CODING IND
1	*Water cycling* (MA 2005)	Required for life and supports all other ESS by constantly renewing the earth's supply of water.	Precipitation patterns	
2	*Sedimentary cycling* (Daily 1997)	Through soil formation it is necessary for a productive earth: absorbs and distributes precipitation to plant roots and surface streams; shelters seeds; provides plants with nourishment and stability; takes care of waste.		
3a	*Nutrient cycling - the carbon cycle* (Daily 1997)	Carbon is the key element of all life. It is stored in the atmosphere, is used in the photosynthesis by plants, which are consumed by animals that use the carbon from the plants in their metabolism, and dead organic material is deformed to CO_2 or redeposited as sediment.	The carbon cycle	Emissions of greenhouse gases, emissions (context), emissions of CO2
3b	*Nutrient cycling - the nitrogen cycle* (Daily 1997)	Nitrogen, in its different forms, is involved in several biological and abiotic processes, e.g. as a compound in the atmosphere and in nitrogen fixation, which is the primary source of nitrogen for living organisms.	The nitrogen cycle	Emissions (context), eutrophication
3c	*Nutrient cycling - the sulfur cycle* (Daily 1997)	Required by living organisms. Sulfur is an important compound of plant tissue and is also consumed by animals and eventually returned to the soil. In its acid form, sulfur has a significant role in different processes, such as natural weathering of rocks acid rain.	The sulfur cycle	Emissions (context)
3d	*Nutrient cycling - the phosphorus cycle* (Daily 1997)	As nitrogen and sulfur, phosphorus is an essential nutrient to plants and animals.	The phosphorus cycle	Emissions (context), eutrophication
4	*Primary production* (MA 2005)	The production of organic compounds at the base of the food chain.		
5	*Photosynthesis* (MA 2005)	Oxygen production required for all aerobic life	Oxygenation of the air by green areas	
6	*Biodiversity* (MA 2005)	Increases ecosystem productivity and stability, essential for all other categories of ESS. Interacts with the atmosphere, geosphere and hydrosphere to make services	Biodiversity, conservation of species, ecologically vulnerable area, ecological	Green linkage, nature care, systems of green areas, ecology (context),

		available.	linkage, linkage (context), natural values, unique species/natural types, nature care (context), valuable green area	corridor, linkage (context), allotment gardening, golf course, pollination, valuable area (context)
7	*Soil Formation* (MA 2005)	Soil organisms process dead organic matter.		

Provisioning services (B)

SD	ESS	NOTES	CODING DIR	CODING IND
1	*Agriculture (food)* (MA 2005)	Source of cereals, dairy products, meat etc.	Agriculture (context), agricultural landscape (context)	Valuable landscape resources
2	*Commercial fishing (food)* (MA 2005)	Source of fish.	Fishery, fishing (in industry context)	
3	*Wild food* (Daily 1997)	Harvesting of wild plants, recreational fishing and hunting of wild animals for meat.	Berries, mushrooms, fishing (in recreational context), hunting	
4	*Fresh water* (MA 2005)	Supplies humans with fresh water for drinking and irrigation and water flows for energy.	Access to water, drinking water, fresh water resources	Water values
5	*Biochemicals and genetic resource* (MA 2005)	Maintenance of the genetic library. Provisioning of genes to biochemicals for pharmacy, cosmetics, crop protection etc.		
6	Forestry (MA 2005)	E.g. wood.	Forestry, timber	Valuable landscape resources
7	Biological energy sources (MA 2005)	Bio-fuels, natural gas	Bio-fuel supply	Bio-fuel (emission context)

Regulating services (C)

SD	ESS	NOTES	CODING DIR	CODING IND
1	*Climate regulation* (MA 2005)	Green areas function as green house gases sinks and cools the regional climate- not least regarding cities as urban heat islands - and benefits the regulation of the global climate. Albedo – reflecting of solar radiation –	Greenhouse gas sink, albedo, evapotranspiration, green area (context), climate	

		cools the local and global climate. Evapotranspiration cools the local climate and alters water redistribution and regional rainfall patterns.	regulation, temperature regulation	
2	*Air quality regulation* (MA 2005)	Some ecosystems function as sinks for different air pollutants, such as NO_x, SO_2 and particulates.	Green areas (in a cleaning context), air cleaning	Clean air (non-specific), air quality (in green area context)
3	*Water purification and Waste Treatment* (MA 2005)	Filtering and decomposing of organic waste material in inland-, coastal- and marine ecosystems, i.e. increases water quality. Water purification can also reduce intake of other contaminants such as toxins and metal waste from industries and traffic. Ecosystems can assimilate and detoxify compounds through processes in the soil. Wetland animals and plants can treat sewage water by slowing down the water flow so particles can settle out on the bottom.	Water cleaning, sewage treatment	Good water quality, dirty lakes, sewage water
4	*Regulation of water flows* (Daily 1997)	Forests preserve watersheds, which are necessary to regulate water flows in quality and quantity.	Regulation of water flows	
5	*Disease regulation – changing abundance of disease vectors, e.g. habitat fragmentation* (MA 2005)	Modifications of ecosystems can increase occurrence of infectious diseases. One example where ecosystems can serve as disease regulators is through preventing spread of Lyme disease.		
6	*Pest control* (Daily 1997)	Natural enemies of pests control the prevalence of crop diseases.		
7	*Natural hazard regulation* (MA 2005)	Wetlands and barrier beaches have a flood storage capacity. Urban ecosystems are especially sensitive due to constrained water flows, which can increase the risk of floods in urban areas. Natural forests are effective protectors of crops and humans from high winds. Some ecosystems have the ability to prevent major fire disasters, which can be futile for plants, animals and the human society.		
8	*Erosion regulation – soil retention* (MA 2005)	Prevents landslides. Most important supplier of this service is forests.		
9	*Pollination* (MA 2005)	Pollination of flowers by insects, wind, birds and water is necessary for sexual reproduction in flowering plant species. Functional composition of pollinator assemblage and connectivity of landscapes are necessary for maintenance of plant genetic pool and quality as well as quantity of fruits.	Pollination, ecological linkage, linked green areas, barrier (context), corridors, linkage (context)	Green linkage, ecologically vulnerable area, big linked area, systems of green areas, ecology (context), linkage (context), allotment gardening

10	*Seed dispersal* (Daily 1997)	Seeds are dispersed by wind, water or by animals in various ways.	Seed dispersal, ecological linkage, linked green areas, barrier (context), corridors, linkage (context)	Green linkage, ecologically vulnerable areas big linked area, systems of green areas, ecology (context), linkage (context), allotment gardening
11	*Habitat connectivity* (Daily 1997)	Connectivity between different green areas make it possible for animal species to move from one area to another, which is positive for biological diversity.	Habitat connectivity, ecological linkage, linked green areas, barrier (context), corridors, linkage (context)	Green linkage, ecologically vulnerable area, big linked area, systems of green areas, ecology (context), linkage (context)
13	*Disturbance regulation - noise reduction* (Bolund and Hunhammar 1999)	A soft lawn reduces noise from e.g. traffic better than concrete ground and vegetation, i.e. shrubbery and dense plantation, also reduces noise at some level. This could also be seen as a cultural service, since a wall of evergreens is visually preferred.	Green areas (in a noise context)	
14	*Invasion resistance* (MA 2005)	Key native species and species-rich communities can hinder invasion of unwanted alien species.	Invasion resistance	

Cultural services (D)

SD	ESS	NOTES	CODING DIR	CODING IND
1	*Cultural diversity, cultural identity and social relations* (MA 2005)	Ecosystem diversity is supposed to increase cultural diversity. Societies have through human history developed closely to natural environment, which therefore is an important factor in forming people's cultural identity and values. Depending on types of ecosystems, different types of social relations are established.	Encounters between people (nature context)	
2	*Cultural landscapes and heritage values* (MA 2005)	Maintenance of historically and culturally interesting landscapes or locally unique species.	Cultural values, of cultural history interest, of cultural interest, cultural landscapes, heritage values, agricultural landscape, ancient remains	

3	*Sense of place* (MA 2005)	People's recognition of features of their specific environment, which can be of value in managing the environment.		
4	*Aesthetic* (MA 2005)	Natural beauty has a supposed pleasure effect for people and is therefore of significant value in urban landscapes.	Scenic views, beautiful nature.	Beautiful environment (in general), gardening, allotment gardening, visual landscape disturbance
5	*Inspirational* (MA 2005)	Inspiration for arts, drama, dance, design, fashion and folklore		
6	*Recreation* (MA 2005)	Recreation has an importance in reflections over changing cultural values and perception. Nature is for many people the place for rest and refreshment. Due to peoples choice of leisure time and eco-tourism it can also be seen as an economic development strategy.	Recreation, tourism (in a nature context), closeness to/access to nature/recreation, strolling area, active outdoor life, golf course, nature silence, park, fishing (context), silence (context)	Good life environment (from a social point of view), closeness (context), walking area (most often)
7	*Educational and knowledge* (MA 2005)	Provides basis for education in different societies. Many traditional societies have evolved empirical knowledge about medicine and food through close relationships to ecosystems.		
8	*Health* (Maas et al. 2006)	Closeness to green areas generates positive health effects to humans.	Health related (green areas context)	Workout (recreation context)

Appendix 2 Key quotes addressing ESS

Quotes primarily follow the order of appearance in respective plan-specific sub-section in section *4.2*. Yet additional quotes follow thereafter, in the order of their *ESS Coding Protocol* denotation. If the ESS in question is not directly addressed, i.e. indirectly addressed, it is here prefixed by "*ind*".

RP 1936

A1 (Water cycling):

"Eke watersheds (boundary between precipitation areas) are marked down on the sketch maps. It is of significance, that the location of the watersheds is regarded at the settlement of land use development proposals. In societies, which fall under more than one precipitation area, essential difficulties and

additional costs at the organisation of sewage systems can easily arise, in case the waste water from one particular society must be lead to more than one recipient." (RP 1936, p. 37)

A6 (Biodiversity):

"The animal life is placed under protection in these areas, next to surrounding reeds. […] with one of the most valuable stand of giant oaks of the Stockholm region. […] Outback lake with rich vegetation." (RP 1936, p. 216- 217)

A6 (Biodiversity), D2 (Cultural landscapes and heritage values) as well as *ind* C9 (Pollination), *ind* C10 (Seed dispersal) and C11 (Habitat connectivity):

"The society (Swedish Society For the Conservation of Nature) has therewith accentuated the importance of, concerning separation of conservation areas, essentially in closeness to a metropolis, as far as possible must seek to preserve large, entire and coherent environments. Hereat the natural delimitations shall be pursued. Concerning preservation of ancient monuments the protected artefacts shall not be left alone and abrupt in an alien or cumbering environment, but rather be preserved in larger groups and contexts alongside the natural surroundings, which is required in order for it to perform in full range." (RP 1936, p. 39)

B4 (Fresh water):

"…take water from the, as water supplier, practically undrainable lake Mälaren…" (RP 1936, p. 11)

C3 (Water purification and waste treatment):

"It is suggested, that the waste water should be lead to lakes (recipients) within the region, namely Saltsjön, Mälaren and some other lakes, of which all have their outlet directly or indirectly to Saltsjön or Mälaren. […] each lake or other water-course (recipient) possesses some self-purification capacity. The emitted organic contaminants are resolved and decontaminated under the influence of biochemical processes. The purification of lakes is distinctly eased if the sewage undergoes such purification that most part of the organic mud is removed prior to emission" (RP 1936, p. 200)

D2 (Cultural landscapes and heritage values):

"The hill fort of Sjöberg with surrounding nature." (RP 1936, p. 217)

D4 (Aesthetic):

"Islet in the waterway with unusually beautiful nature. […] Ravine with rich vegetation, unusually gross and gorgeous pines." (RP 1936, p. 216-217)

D6 (Recreation):

"The Rösjö area. The area suitable for a nature park." (RP 1936, p. 217)

RP 1958

A6 (Biodiversity) as well as *ind* C9 (Pollination), *ind* C10 (Seed dispersal) and *ind* C11 (Habitat connectivity):

"An inner coast and archipelago belt in the eastern part of the region is dominated by leisure areas, while green area […] make up an essential part of the landscape scene southward. A coherent conservation area engrosses the entire outer archipelago belt" (RP 1958, p. 2)

A6 (Biodiversity) and D6 (Recreation):

"However, the wider extent leisure habitation acquires, the more important it is that it is the most valuable parts from a recreational and a landscape perspective most valuable parts that are conserved and left untouched by habitation. Therefore it has been considered meaningful to mention certainly fine and tender parts of the archipelago as areas reserved to be left non-habited (essential in a landscape preserving intent)." (RP 1958, p. 43)

B1 (Agriculture [food]) and B2 (Commercial fishing [food]):

"The same goes for agriculture in the inland parts of the region, which should be accessible for a further pushed rationalisation. […] Fishing, which is an important source of livelihood in this area, alone or in combination with agriculture, has during the last 20 years by contrast to the remaining part of east coast fishing developed slightly with regard to draft volumes. A continued rationalisation of the industry and thereby a decrease of fishermen is awaited." (RP 1958, p. 29)

B4 (Fresh water) as well as *ind* C3 (Water purification and waste treatment):

"For those parts of the region situated close to Mälaren, crude water supply is for certain unlimited […] As for the rest of the region, water supply will probably even henceforth be built on ground water recourses, in some cases with addition of surface waters through infiltration." (RP 1958, p. 43)

D6 (Recreation):

"The Stockholm region offers its citizens good opportunities to outdoor life in different forms. The large forest areas of Södertörn and some vicinities north of Stockholm are traditionally carefully used… […] Due to the advancement of the car (culture), outdoor life has more and more developed to some sort of excursions to forest areas, bathing places or to a rural vicinity of relatively large distance from urban development. Recreation then consists of the travelling itself and the resulting experiences of the landscape, in combination with a bush-walk, bath or a moment of rest in the free." (RP 1958, p. 29)

S 1966

A1 (Water cycling) and B4 (Fresh water):

"Precipitation affects the entire biological cycle and concerning physical planning, precipitation areas must be regarded in exploitation of ground water resources and lakes for fresh water supply for the

society. […] Precipitation in form of snow affects the qualities of an urban area… […] In a habitation area, snow has a stimulating effect on the outdoor games of children, which must be considered in detailed planning." (S 1966, p. 155)

A6 (Biodiversity):

"In the choice of areas for open-air life, it is important to take nature care aspects into account. However, not to the extent that well-situated and of other reasons valuable areas are ... civic functions in order to spare vulnerable flora from wasting. Such exclusive nature care should only with exception occur in a metropolitan region." (S 1966, p. 120)

A6 (Biodiversity) and D6 (Recreation):

"But also nature care in regard to protection of valuable nature areas from degradation and destruction is desirable. In a metropolitan region, all open-air areas will be subject to certain degradation. Awareness of the problems of maintaining the latter form of nature care in the closest metropolitan surroundings is needed. The protective nature care can however be managed in a modified form. It is for instance possible to lead the large flow of people past sensitive areas through planning of roads and such. It is namely well known that people in general don't move far away from roads. Such protective nature care shall of course not be driven too far, since the need for open-air areas close to the metropolis is great, and since citizen's accessibility to the most attractive areas should be an ambition." (S 1966, p. 119)

B1 (Agriculture [food]), B6 (Forestry), D6 (Recreation) and D4 (Aesthetic value):

"Agriculture and forestry also have a purely landscape preserving function, since the beauty of many landscape types is dependent on the cultivation method." (S 1966, p. 120)

B2 (Commercial fishing [food]):

"In question of the development of fishing in the region in the long-run, there is a lack of closer studies. It is conceivable that certain commercial fishing at a smaller scale will be continued in different places along the coast and this should be considered at detailed planning of the coastal societies." (S 1966, p. 50)

B4 (Fresh water):

"For greater Stockholm, […] it is a essential condition to be able to get fresh water for consumption from Mälaren." (S 1966, p. 166)

C2 (Air quality regulation) and *ind* A3c (The sulfur cycle):

"The role of green areas as dust separator or filter is not yet fully made clear. Observations indicate that the values of green areas from a pollution pint of view are mainly psychological and merely to some extent bind dust, since sulphur dioxide values hardly seem to be reduced." (S 1966, p. 159)

C3 (Water purification and waste treatment):

"It has long been considered natural to let watercourses be tipping points for waterborne waste – which has been able to happen as long as it has been a question of limited emissions that have enabled self-purification." (S 1966, p. 161)

C3 (Water purification and waste treatment):

"In the studied section, there are possibilities for emissions in relatively large water areas with good circulation in the archipelago. […] Settling and preferably some form of biological low degree purification will probably be what is needed for the mentioned, not very large, sewage emissions." (S 1966, p. 177)

D2 (Cultural landscapes and heritage values) and D4 (Aesthetic value) as well as *ind* C9 (Pollination) and *ind* C10 (Seed dispersal):

"Allotment areas. The areas have been reserved for open-air life purposes because they are of certain value as excursion areas through their attractive nature or because they consist of cultural heritage of common interest." (S 1966, p. 222)

D4 (Aesthetic value):

"It is obvious that different landscape types and locations provide various conditions for the creation of a beautiful city milieu. The ambition is therefore, when new areas of exploitation are considered, that not only technical and economic factors should be taken into account, but also the conditions of the areas for the development to beautiful urban passages" (S 1966, p. 41)

D6 (Recreation):

"As playing-fields and parks are necessary complements to the dwelling areas in the district and promenade areas to different urban districts, the leisure zone is a necessary complement to the metropolis as entirety." (S 1966, p. 118)

D6 (Recreation) as well as A3b (The nitrogen cycle) and A3d (The phosphorus cycle):

"Concerning bathing, it can shortly be insisted that the increasing production of primarily water blooming cyan bacteria, which most certainly will take place due to addition of nutrient salts from the waste water, also would imply clearly abate comfort." (S 1966, p. 167)

D6 (Recreation), B3 (Wild food) as well as *ind* D8 (Health):

"Outside the densely built part of the region, areas for different kinds of excursions are needed; fishing, mushrooming, berry picking, workout walks, skiing, bathing and boating. A large part of these recreational and outdoor life areas shall be city based, i.e. primarily be used by people on day trips." (S 1966, p. 118)

D6 (Recreation), B1 (Agriculture [food]) and B6 (Forestry):

"This near zone for public outdoor life is intended to remain agricultural or forestry land as it looks today, but the agricultural livelihoods within the area should be pursued in a way that doesn't neglect outdoor life interests." (S 1966, p. 221)

RP 1973

B4 (Fresh water):

"Crude water for the needs of greater Stockholm is in the main taken from Mälaren at five water plants." (RP 1973, p. 57)

D6 (Recreation):

"Beyond the areas directly connected to development of greater Stockholm, areas shown as recreation areas are: the major part of the archipelago as well as some other areas, of which the largest areas are an area around Roslags-Kulla in Österåker, an area around lake Yngern in Södertälje and an area by lake Erken in Norrtälje." (RP 1973, p. 46)

RP 1978

A6 (Biodiversity) and D2 (Cultural landscapes and heritage values):

"Land comprising essentially valuable natural conditions such as unusual flora and interesting fauna as well as cultural heritage should be protected and managed so that their specific character is preserved." (RP 1978, p. 77)

B1 (Agriculture [food]) and B6 (Forestry):

"Good agricultural and forestry land should be preserved for its purposes - arable land should not be claimed if a, for societal development, more satisfactory solution could be realised on land which is less valuable for agricultural needs." (RP 1978, p. 77)

B4 (Fresh water):

"Water supply is continuously assumed to be provided by surface water catchments, mainly by Mälaren, Bornsjön and Erken (Norrtälje)." (RP 1978, p. 86)

D4 (Aesthetic value):

"Land that is of greater importance for the outdoor life due to nature beauty." (RP 1978, p. 78)

D6 (Recreation):

"Residing development is in the regional plan suggested to be localised and designed in such a manner that good accessibility to green areas is obtained." (RP 1978, p. 32)

RP 1991

Ind A3b (The nitrogen cycle) and *ind* A3d (The phosphorus cycle):

"Nutrients mainly originating from agriculture, food-processing industry and the municipal sewage plants fertilise the recipients. Vegetation grows denser and changes its nature." (RP 1991, p. 33)

ind A3c (The sulfur cycle) and *ind* A3d (The phosphorus cycle):

"The main source for acidification is the (acid) rain of sulphur and nitrogen. Around 80 percent of this comes from without the region. In the inner city of Stockholm, where the pressure is several times higher than farther, the region itself accounts for most of the acid rain. […] Carbon dioxide, mainly from street traffic, threatens climate (the green house effect)." (RP 1991, p. 32)

A6 (Biodiversity), C10 (Seed dispersal) and C11 (Habitat connectivity):

"The preservation of the area is thereby essential. In order to preserve species diversity in the area, a contact with the Tyresta-Åva area is needed." (RP 1991, p. 113)

A6 (Biodiversity) and D6 (Recreation):

"…large areas which in the main are not affected by exploitation, ecologically sensitive areas, areas valuable with regard to their nature or cultural values, valuable recreation areas, especially close to urban development." (RP 1991, p. 32)

B4 (Fresh water):

"Close to one and a half million people in the county receives their fresh water from Mälaren. […] Back-up capacity is mainly provided by Bornsjön and some municipal back-up water reserves." (RP 1991, p. 58)

Ind B7 (Biological energy sources):

"More environment friendly vehicles are needed […]cars run by bio-fuels […] based on different bio-fuels." (RP 1991, p. 54)

C9 (Pollination), C10 (Seed dispersal) and C11 (Habitat connectivity):

"The green belt of greater Stockholm consists of biological core areas within a distance of 25 kilometers from the city centre and connected to each other so that spread of species can occur between the areas. Since the green wedges are interconnected, they can recover better after disturbances. Where dispersal corridors are narrow, small additions of habitation severely affect the areas they connect." (RP 1991, p. 56)

D2 (Cultural landscapes and heritage values):

"Mörkö: Mid and north parts of Mörkö are of national interest for cultural heritage conservation, for instance due to Hörningsholm castle and the cultivation environment of Oax. Large sections of the

island have very high natural values with for instance shore meadows, birdlife and limestone vegetation." (RP 1991, p. 123)

RUFS 2001

A1 (Water cycling):

"The blue structure (of the region) is part of the hydrological cycle and thereby part of a larger flow which doesn't take administrative borders into account. This implies that policy measures in the surrounding world affects the possibilities of a particular municipality to manage and plan the use of its fresh water resources. Since planning for a sustainable water management must embody a drainage area, an increased inter-municipal cooperation is necessary." (RUFS 2001, p. 52)

Ind A3b (The nitrogen cycle), *ind* A3c (The sulfur cycle) and *ind* A3d (The phosphorus cycle):

"Acidification, eutrophication of water-courses, contamination of land and water through use of chemicals, poor air quality and noise in conurbation as well as competition of land are some of the most important environmental issues in the region." (RUFS 2001, p. 22)

A6 (Biodiversity):

"Several nature types and valuable green areas are at the present non-protected. An analysis of which values respective area contains and of what threats towards them can be at hand implies that some areas should be protected by regulations according to Environmental Code." (RUFS 2001, p. 52)

A6 (Biodiversity), C9 (Pollination) C10 (Seed dispersal) and C11 (Habitat connectivity)

"In the region, there is a unique coherent metropolitan green structure consisting of ten green wedges interconnected by green corridors. The green structure has a great value and provides the region citizens with access to large outdoor life areas. The green areas also hold core areas of significance for the biological diversity." (RUFS 2001, p. 22)

A6 (Biodiversity), C9 (Pollination), C10 (Seed dispersal) and C11 (Habitat connectivity):

"Large coherent green areas also important for the biological diversity and function as ecological support systems." (RUFS 2001, p. 51)

A6 (Biodiversity), D2 (Cultural landscapes and heritage values) and D6 (Recreation):

"A sustainable environment for life in the long run, implies a built environment which is healthy and comprises beauty and comfort values. It also implies that green structure, water resources as well as nature and cultural values are protected and preserved and that biodiversity is maintained." (RUFS 2001, p. 10)

B4 (Fresh water):

"The great dependency of Mälaren for fresh water supply means that big water reserves are needed if the water of Mälaren would be unusable. Access to such reserves is however limited. Back-up

catchments are mainly Bornsjön, the ground water catchments of Norrvatten as well as some municipal water catchments." (RUFS 2001, p. 54)

B7 (Biological energy sources):

"Bio-fuel supply is limited within the county. In the long-run, it can, together with decay products from industry and households cover a minor part of the energy demand." (RUFS 2001, p. 86)

D2 (Cultural landscapes and heritage values):

"New habitation and new facilities in the Urban National Park can only be brought about and measures be taken if it can be carried out without intrusion in the park landscape and natural environment and without harming the natural and cultural values of the historical landscape." (RUFS 2001, p. 103)

D6 (Recreation) and D8 (Health):

"Contact with green areas and parks leads to reduced physical and psychic complaints amongst humans; stress declines, ability to concentrate decreases and illness heals faster. The human need for nature contact is of certain significance in a metropolis with an intense living tempo and an intense physical environment." (RUFS 2001, p. 51)

D8 (Health):

"Research has showed that nature is a particularly healing power against different states of stress. Measures that aim to preserve and develop the green areas of the region as well as to shield silent areas in particular increase the conditions for a good health." (RUFS 2001, p. 50)

RUFS 2010

A1 (Water cycling):

"One of the most noticeable climatic changes in the county is related to precipitation patterns. There will probably be essentially more precipitation in the winter and less in the summer. These changes can imply a series of effects such as increased instability in slopes and risk for floods." (RUFS 2010, p. 77)

A1 (Water cycling), B4 (Fresh water) and D6 (Recreation):

"The fresh water resources and the natural ecosystems must be preserved. Also, the citizens and tourists must continuously be able to use the water of the region for recreation. The increasing population implies a large demand both on water as a resource and on environments near water. The regional water catchments shall be preserved. Regard must be taken both to ground water incidence as to lakes, as well as to their catchment areas." (RUFS 2010, p. 131)

Ind A3a (The carbon cycle):

"We will need to regard those emissions of greenhouse gases that we generate through our consumption patterns. We will also need to 'catch' carbon dioxide in the atmosphere in order to manage the 2-degree-goal." (RUFS 2010, p. 71)

A6 (Biodiversity):

"Climate change also affects biodiversity and the natural environment, since a change in the climate affects a whole range of processes that control the structures and functions of ecosystems. […] With a drastic increase in temperature, Stockholm could already to the end of the century expect a climate comparable to that of today's Berlin, which implies a high risk for major changes in the ecosystems of the county." (RUFS 2010, p. 69)

A6 (Biodiversity), B2 (Commercial fishing [food]), B4 (Fresh water), C3 (Water purification and waste treatment), D6 (Recreation) as well as *ind* A3b (The nitrogen cycle) and *ind* A3d (The phosphorus cycle):

"Water has great importance as fresh water resource, as recipient for sewage and surface water, as natural ecosystem and for recreation. However, eutrophication and emissions of unwanted matter to the water continues to negatively affect fresh water quality, recreational values, biodiversity and commercial fishing. According to the EU Water Framework Directive, the goal of Good Ecological status should be achieved already by year 2015." (RUFS 2010, p. 68)

A6 (Biodiversity), C9 (Pollination), C10 (Seed dispersal) and C11 (Habitat connectivity):

"… high biodiversity and variation diversity, which creates conditions for reproduction and dispersal of animals and plants. […] The areas should be kept coherent and protected against fragmentation." (RUFS 2010, p. 153-154)

A6 (Biodiversity), *Ind* C9 (Pollination), C10 (Seed dispersal) and C11 (Habitat connectivity):

"Major barrier effects affecting humans and animals should be avoided or adjusted in order to strengthen the green wedges as a coherent space. […] Inter-municipal cooperation can strengthen the connectivity through coordinated management and facility measures. Such cooperation should also regard the possibilities to strengthen certain experience values." (RUFS 2010, p. 100)

B1 (Agriculture [food]) and B6 (Forestry):

"The land outside conurban areas has a versatile character and use: agriculture, forestry, recreation areas, water catchment and not at least a large spread population. […] new development should connect to present development and conurbation." (RUFS 2010, p. 125)

B7 (Biological energy sources):

"Investments for biogas should be promoted in connection to sewage plants as well as in waste management and farm plants." (RUFS 2010, p. 148)

C1 (Climate regulation), C2 (Air quality regulation) and C4 (Regulation of water flows):

"The wedges also have a function of infiltration, purification or regulation of surface water flows (so called ecosystem services) for air purification and for regulation of temperatures." (RUFS 2010, p. 94)

D1 (Cultural diversity, cultural identity and social relations):

"Closeness to nature is an important quality of a metropolis. Access to a varied nature, beaches and water environments stimulate physical, provides opportunities to relaxation, silence, games and nature and cultural experiences close to home. Sites for activity, open-air facilities and events in natural environments contribute to more encounters between people." (RUFS 2010, p. 101)

D6 (Recreation):

"Thanks to the stance of policy concerning densification, the result is that the citizens continue having good access to the regional green structure." (RUFS 2010, p. 189)

D8 (Health):

"The wedges as a coherent area has however no formal protection. No initiatives have been taken on national, regional and municipal level for the insurance, development and integration of the values of the near urban nature from a public health and city development perspective." (RUFS 2010, p. 94)