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ORIGINAL PAPER

Using the ecosystem services approach for better planning and conservation of urban green spaces: a Finland case study

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Abstract Ecosystem services are vital for humans in urban regions. However, urban development poses a great risk for the ability of ecosystems to provide these services. In this paper we first address the most important ecosystem services in functional urban regions in Finland. Well accessible and good quality recreational ecosystem services, for example, provided by urban nature, are an important part of a high-quality living environment and important for public health. Vegetation of urban regions can have a role in carbon dioxide sequestration and thus in climate change mitigation. For instance, estimates of carbon sinks can be compared to total CO_2 emissions of an urban region, and the municipality can aim at both increasing carbon sinks and decreasing CO_2 emissions with proper land-use planning. Large and contiguous core nature areas, smaller green areas and ecological connections between them are the essence of regional ecological networks and are essential for maintaining interconnected habitats for species and thus biological diversity. Thus, both local and regional level ecological networks are vital for maintaining ecosystem services in urban regions. The impacts of climate change coupled with land-use and land cover change will bring serious challenges for maintaining ecosystem services in urban areas. Although not yet widely used in planning practices, the ecosystem services approach can provide an opportunity for land-use planning to develop ecologically sustainable urban regions. Currently, information on ecosystem services of urban regions is lacking and there is a need to improve the knowledge base for land-use planning.

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Introduction

Ecosystems provide vital services to humans (MA 2005). However, the ability of ecosystems to benefit human population is jeopardized by human actions. One of these actions is urbanisation. Finland, for instance, has urbanized quickly in recent decades and the expansion of urban areas continues. Finland's urban population grew almost 3% between 2000 and 2005, and is currently 84% of the total population of 5.3 million (Tilastokeskus 2008). As a result of urbanization (including urban sprawl) the transportation network in Finland has spread out so that several urban regions have expanded to form broad economic and commuting areas (EEA 2006). Such "counter-urbanization" (Mitchell 2004) is maintained in Finland by the migration of educated families to municipalities surrounding core urban areas (Broberg 2008). In Finland, as in many European countries, the recent trend in life styles and land-use is that single and semi-detached houses are being built ever further away from centres of commerce, resulting in longer commuting distances (Helminen et al. 2003; Helminen and Ristimäki 2008). Consequently, built-up areas use more and more land per urban inhabitant (EEA 2006).

The geographical expansion of urban areas has resulted in the fragmentation and isolation of urban green spaces from rural green areas (Väre and Rekola 2007). Furthermore, land-use and land-cover changes have had a negative effect on the original biological diversity in urban areas (Heikkinen 2007; Grimm et al. 2008). As ecosystem services are produced by biodiversity, the disappearance of biodiversity adversely affects services provided by ecosystems to humans (MA 2005; Naskali et al. 2006). On the other hand, human actions can increase the diversity of urban nature (Savard et al. 2000), although the composition of species is different from that found in pristine or rural nature. It is, therefore, important to identify what kinds of ecosystem services urban regions provide, and how these are shaped by human actions.

In this paper, we identify ecosystem services generated by urban regions, and examine trade-offs and conflicts related to these services from the viewpoint of local residents. We deal with ecosystem services at the scale of urban regions, rather than at the scale of a city. This is because a city as an administrative unit is interacting with its surroundings and thus cannot realistically be considered a functional unit for ecosystem services. We identify what we consider to be essential ecosystem services in urban regions, and discuss these by providing examples. We also examine the potential of using the ecosystem services concept in land-use planning, and conclude with providing some challenges for future research.

Ecosystem services of urban regions and factors affecting them

Types of ecosystem services in urban areas

Ecosystem services provided by urban green areas, such as recreational services, are difficult to distinguish from services provided by areas surrounding the cities due to interactions between urban areas and their rural surroundings. As such, we evaluate ecosystem services provided by urban regions that are larger than urban areas or cities. An urban region is defined by using the Finnish database "Monitoring System of Spatial Structure", which is a GIS-based database and planning toolkit developed by the Finnish environmental administration. The system offers, for example, register-based two-way commuting data for the whole of Finland for five-year periods, starting from 1985. The database is at a spatial resolution of 250 × 250 m for the whole of Finland and provides data separately for the functional areas into which the country has been divided (Helminen and Ristimäki 2007).

According to this system, a functional urban region consists of an urban centre and surrounding built-up areas (towns, villages) with intervening rural areas. Whether an area belongs to an urban centre is determined by distance from the central urban area, percentage of people working in the centre, degree of connectivity between urban areas, and the characteristics of areas between these urban areas. The urban region of Lahti, which is based on this definition (data from 2005) is used in an analysis shown in Fig. 1. However, in reality urban regions form a gradient from highly modified urban cores to almost untouched green areas in the outskirts of urban regions (McDonnell and Pickett 1990). Such urban environments are an outcome of interactions of socio-economic and biophysical processes, and are complex systems (Alberti and Marzluff 2004). In Finland, for example, distinct urban–rural gradients are most easily detectable in large cities, whereas in many smaller towns, boundaries between compact urban centres and sparsely populated rural areas are often more distinct, and actual urban–rural gradients are not detectable.

Urbanization and land-use changes alter landscape structure and ecosystems (Grimm et al. 2008), affecting native species negatively. These human-caused disturbances may also diminish the resilience of ecosystems, i.e. the ability of ecosystems to tolerate disturbances and recover so that essential functions and structures are retained (Colding 2007). The ecosystem services concept may help in integrating urban natural and social scientific research, consequently resulting in the successful application of research findings in urban planning, urban governance and maintenance of biological diversity (Lyytimäki et al. 2008). Although research and policy interests towards ecosystem services have grown considerably in recent years (e.g. Daily and Matson 2008), ecosystem services of cities or urban regions have not been studied much. This lack of information on urban ecosystem services has resulted in a situation in which land-use planning and management decisions are based on inadequate information on the benefits that humans can derive, for example, from urban parks and forests. This may result in underestimating ecosystem services (Kremen and Ostfeld 2005). If the impacts of land-use changes on ecosystem services are not assessed beforehand, there may be considerable costs involved in the loss or restoration of these services. Some of these costs can be measured in economic terms (e.g. diminished water provision, increased flood damage) but many are difficult to quantify (e.g. loss of cultural values and recreational services).

In this paper, ecosystem services are classified into provisioning, regulating and cultural services (MA 2005). Provisioning services are material benefits that ecosystems generate, such as food, fresh water or timber products. Regulating services regulate e.g., climate and air quality, hydrological and biochemical cycles and soil processes, and are essential preconditions for other ecosystem services. Cultural services are immaterial benefits that humans obtain from ecosystems, for instance by recreation, health benefits or the accumulation of knowledge (MA 2005).

In Table 1 we classified ecosystem services of urban regions into provisioning, regulating and cultural services. Urban ecosystem services benefit city dwellers in particular, whereas ecosystem services of urban regions benefit the dwellers of both cities and the

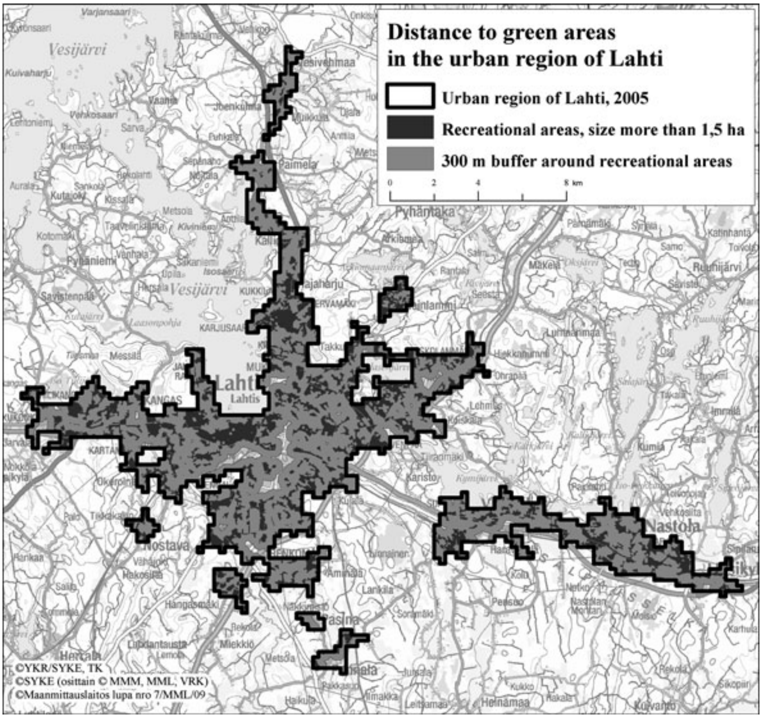

Fig. 1 The urban region of Lahti (area outlined in *black* illustrates the urban region based on the Finnish database "Monitoring System of Spatial Structure", see text). *Dark grey* areas illustrate *green* areas available for recreation. A high-quality living environment is defined as a living space with *green* areas suitable for recreation within reach. A recommended maximum distance of such an area from home is 300 m. *Green* areas presumably suitable for recreation were selected from CORINE Land Cover 25 m national data. The minimum recommended size of a local recreation area is 1.5 ha. *Green* areas smaller than 1.5 ha were excluded from the analysis presented in the figure. A 300 m buffer zone (*light grey* areas) was calculated for the remaining *green* areas. Inhabitants living in the buffer zone thus have a *green* area suitable for recreation close by. Subsequently, the Lahti urban region was outlined (produced by the Finnish Environment Institute) and areas that do not fulfil the standard of a high-quality living environment—regarding the attainability of *green* areas—were identified. Roughly 5.3% of the population live too far away from *green* areas. In a more specific analysis, different barrier effects could also be considered. For instance, large roads or waterways can prevent the use of a recreational service, which is otherwise close by

surrounding rural areas (see Gutman 2007). However, classifying ecosystem services is case dependent: in cities, ecosystem services and biological diversity can be assessed, for instance, at the species or habitat level, but in larger areas an ecosystem or a landscape is a more appropriate level of assessment. In addition, the impacts and importance of some services, such as carbon sequestration and storage, are global, whereas others, such as recreational services and the regulation of microclimate are mainly local.

The importance of various ecosystem services differs between urban and rural areas. Some nationally significant provisioning services are not particularly important in urban regions. In Finland, such services are the large-scale production of food, raw materials and genetic resources. However, there are exceptions, for instance in some urban regions the production of food or raw timber material can be significant. This is the case in smaller Finnish towns with administrative boundaries extending well into the surrounding

Table 1 Examples of ecosystem services provided by green and water areas in urban regions (adapted from Kremen 2005)

Group	Ecosystem service	Service generating unit	Reference
Provisioning services	Timber products	Different tree species	Matero et al. (2003)
	Food: game, berries, mushrooms	Different species in land, fresh-water and sea ecosystems	Matero et al. (2003)
	Fresh water, soil	Groundwater infiltration, suspension and storage	Matero et al. (2003) Brauman et al. (2007)
Regulating services	Regulation of microclimate at the street and city level → changes in heating costs	Vegetation	McPherson et al. (1997) Jo and McPherson (2001)
	Gas cycles → O_2 production, CO_2 consumption	Vegetation, especially forests	Lebel et al. (2007) McHale et al. (2007)
	Carbon sequestration and storage	Vegetation, especially trees	Balvanera et al. (2005)
	Habitat provision	Biodiversity	de Groot et al. (2002)
	Air pollution purification	Vegetation covered areas, soil microorganisms	Givoni (1991) McPherson et al. (1997) Nowak et al. (2006) Bowker et al. (2007)
	Noise cushioning in built-up areas and by transportation channels	Protective green areas, thick/wide forest, soft surfaces	AAC (2002)
	Rain water absorption → Balancing storm water peaks	Vegetation cover, sealed surface, soil	Bolund and Hunhammar (1999) Guo et al. (2000)
	Water infiltration	Wetlands (vegetation, micro-organisms)	Ewel (1997) Bolund and Hunhammar (1999)
	Pollination → Maintaining floral populations → food production	Insects, birds, mammals	Nabham and Buchmann (1997) Thomson and Goodell (2001)
	Humus production and maintaining nutrient content	Litter, invertebrates, micro-organisms	Daily et al. (1997) de Groot et al. (2002)

Table 1 continued

Group	Ecosystem service	Service generating unit	Reference
Cultural services	Recreation of urban dwellers	Biodiversity, especially in parks, forests and water ecosystems	Postel and Carpenter (1997) Bolund and Hunhammar (1999) Arnberger (2006)
	Psycho-physical and social health benefits	Forest nature	Grahn and Stigsdotter (2003) Butler et al. (2005) Gidlöf-Gunnarsson and Öhrström (2007) Hansmann et al. (2007) Tzoulas et al. (2007)
	Science education, research and teaching	Biodiversity	Bolund and Hunhammar (1999) Matero et al. (2003)

countryside. On the other hand, cultural ecosystem services provided by urban green areas are one of the most important ecosystem services from the perspective of urban dwellers.

Recreation as an ecosystem service

Recreational ecosystem services provide possibilities for, e.g. outdoor recreation, nature observation, education, photography, picking wild berries and mushrooms, hunting (in the outskirts of urban regions), boating, swimming and fishing. Areas suitable for local recreation in urban regions are variable and are located in human-influenced environments: parks, forests, meadows, marshlands, grasslands, rocks, water fronts and water areas. In urban areas even small green areas can be significant for human recreation especially when it comes to young people. In a study on teenage experiences of public green spaces in suburban Helsinki, the adolescents mentioned, along with the most popular areas, various ''invisible'' green spaces, such as small woodlands that for the adults were mainly transitory areas or green elements in the housing environment (Mäkinen and Tyrväinen 2008).

Many of the recreational services used by urban dwellers, such as hunting or berry picking, are in fact ecosystem services provided by the surrounding rural areas. Local forests located in built-up areas are used for daily outdoor recreation while recreation and green areas beyond built-up areas are mainly used for weekend hiking or excursions (Arnberger 2006).

Recreational services can be provided by the public sector, such as local and outdoor recreation parks maintained by municipalities, outdoor recreation areas by e.g. recreation area associations, or national parks and other nature conservation areas by the state. However, visitor numbers in nature conservation areas or national parks located in or close to urban regions can be so high that the conservation of these areas may be compromised

(Borgström 2008; Sterl et al. 2008; Wagner et al. 2005). There may thus be a conflict between nature conservation and recreation in such areas in or around densely populated urban regions (Zaikanov and Kiseleva 2008). In such cases the responsibility of municipalities in generating diversified and good-quality local recreational services, alongside nature conservation areas, is important (Arnberger and Brandenburg 2007).

A large part of recreation on privately owned land takes place through *Everyman's right*, which is a traditional Finnish legal concept that allows free access to land and waterways, and the right to collect natural products such as wild berries and mushrooms, regardless of who owns the land (Finnish Environment 2008). Furthermore, agricultural or forestry land suitable for recreation may be used or passed through because of the concept of everyman's right. Thus, private land suitable for recreation should be identified to complement land that has officially been set aside for recreational services. This can be achieved with the aid of CORINE Land Cover data for land-use and land cover (Fig. 1).

Ecosystem services provided by urban nature are an important part of a high-quality living environment (MA 2003; Tzoulas et al. 2007). This means sufficient recreation areas, good accessibility (especially on foot), connectivity, and ecological diversity. The accessibility of recreational services is important for public health (e.g. de Vries et al. 2003; Korpela and Ylén 2007). A well accessible and good quality recreational environment attracts people to exercise, which has great importance in a country where people are increasingly employed in static and computerizing work (Tzoulas and Greening 2010). Good accessibility is especially important for children, disabled people, and the growing aging population. According to Wiik (2005) a child at primary school level plays only within 300 m from home. People with restrictions in sight, hearing or movement also need improved structures for recreational services, such as easily passable routes. In addition, a silent environment (Carles et al. 1999; Pesonen 2005; Gidlöf-Gunnarsson and Öhrström 2007), and adequate distances from air polluting sources are part of a high-quality recreational environment. The latter is especially important for the outdoor recreation of people with chronic respiratory or heart diseases (EFA 2009). Moreover, maintaining connectivity to surrounding green areas is a precondition for ensuring the conservation and ecological quality of such areas.

Recreational services provided by urban nature are threatened by insufficient planning and maintenance (Zaikanov and Kiseleva 2008; Borgström et al. 2006). In order to protect urban nature, it is advisable to manage visitor flows, especially in heavily used green areas, with well planned and constructed routes (see Hamberg et al. 2008; Malmivaara-Lämsä et al. 2008). Moreover, such areas require regular maintenance and monitoring to ensure the proper functioning of recreational services (DeLucio and Múgica 1994). The function of recreation areas is also threatened by construction particularly in growing urban regions. In Finland, this is the case in the metropolitan area of Helsinki (Borgström et al. 2006).

Consolidating urban structure due to climate change mitigation can lead to the loss of green areas (Henriksson and Jääskeläinen 2006). Such loss can in fact result in an undesirable outcome from the perspective of climate change mitigation, as urban dwellers have to commute to find recreational services. It has been shown that when the distance to an area suitable for outdoor recreation exceeds one kilometre, people travel there by car (Neuvonen and Sievänen 2008). Thus, there can be conflicts in urban regions if ecosystem services exclude each other as the examples above illustrate.

Recreational services have economic importance. Tyrväinen and Miettinen (2000) showed that urban apartments in close proximity to forest and water areas are more highly priced than those further away. Recreational services are also important for tourism, as nature-related issues often influence the decisions of foreign tourists to travel to Finland

Table 2 Minimum sizes and maximum distances from housing areas to recreation areas in urban regions (Pouta and Heikkilä 1998)

Park type	Minimum area (ha)	Maximum distance from a housing area (m)
Local park	1.5–3	300
Outdoor recreation park	20–25	1,000
Outdoor recreation area	100–200	1,000–15,000

(Krzywacki et al. 2008). Not much information exists on how important recreational services are considered when companies decide the best location for their offices. However, qualities of the natural environment (such as recreational values) are important for the location of rural businesses (Johnson and Rasker 1995).

Unlike other ecosystem services, recreational services have been, for a long time, considered important and they have also been regulated by legislation in Finland. According to the National Land Use Guidelines issued by the Council of the State (Ministry of the Environment 2000; Finnish Environment 2009) "ecologically and recreationally important, significant and cohesive natural areas should be taken into account in planning, and land-use should be directed as not to split up entities unnecessarily". Also, the preservation of so-called quiet areas should be promoted. In the specific goals for the Helsinki metropolitan area, the Land Use Guidelines state that land-use should guarantee that sufficiently extensive and attractive recreation areas are available for the need of the population, extending across the borders of municipalities. Land-use should also guarantee the continuity of the green network connecting these areas. According to the Land Use and Building Act (1999), an objective of land-use planning is to promote safe, healthy, pleasant and socially functional living and working environments, which also provide recreational services for the needs of various population groups, such as children, the elderly and the disabled. Moreover, recreational services have to be considered in planning, and land-use planners have to make sure that there are enough parks and other areas suitable for local recreation in the area covered by the plan or in its vicinity. Furthermore, the Land Use and Building Act (1999) states that it is primarily the task of the municipality to organize opportunities for outdoor recreation and recreational services to citizens. In order to ensure good quality living environments, the environmental administration has developed recommendations on minimum sizes for recreation areas and maximum distances from housing to recreation areas (Table 2).

Carbon dioxide sequestration as an ecosystem service

Carbon sinks can be addressed at two spatial scales: within the city and at the urban regional level. Within a city park, green areas and tree plantings can function as carbon sinks (McHale et al. 2007), although urban vegetation only sequestrates a small part of annual CO_2 emissions of a city (Jansson and Nohrstedt 2001; Lebel et al. 2007). In fact, urban parks can function as carbon sources because management and the use of parks produce multiple amounts of CO_2 emissions compared to the carbon sequestration capacity of a green area (Oliver-Solà et al. 2007). On the contrary, shading trees can decrease the amount of energy needed to cool buildings, and trees reducing wind speeds decrease the need for heating energy. Creating such positive impacts requires careful planning of land-use and green plantings (McPherson 1998; Jo and McPherson 2001; McPherson and

Simpson 2003). Although urban carbon sinks do not necessarily have a significant impact on the global carbon balance, urban green areas can have local importance as carbon sinks.

There are some macro-scale estimates of CO_2 emissions and sinks from urban regions. The land area of Stockholm County (7240 km^2), Sweden, is capable of sequestrating 41% of the total emissions created by transport and 17% of all human-caused CO_2 emissions (Jansson and Nohrstedt 2001). Compensating CO_2 emissions in the Stockholm county area would require 20170 km^2 of forest, wetland or water areas, i.e. almost three times the area of the county. Currently, the area of these natural environments is 53% of the county area.

When examining the carbon sinks of urban regions, GIS methods are essential in estimating the quantity, quality and carbon sequestration capacity of various urban environments. Tratalos et al. (2007) studied the quantity of five ecosystem services (including carbon sequestration) in different urban areas (core urban centre, area close to the centre, and suburb) with GIS methods. Although the quantity of the studied services decreased towards densely built centres, careful planning can improve the functioning of ecosystem services (Tratalos et al. 2007). According to Whitford et al. (2001), the quantity of urban ecosystem services, e.g. carbon sequestration, can relatively easily be studied using aerial photographs, focussing the analysis on the amount and type of vegetation cover, especially trees.

In Finland, a recently launched multi-stakeholder programme "Carbon Neutral Municipalities" intends to create tools and models for municipalities to mitigate climate change and to develop a carbon neutral mode for each municipality (Finnish Environment Institute 2008). Achieving carbon neutrality requires consideration of all carbon fluxes. Therefore, the location of green areas and the commuting mode to and from these green areas are included as variables in the calculations. For instance, travelling to a recreation area close to a city, reachable by public transport, produces less CO_2 emissions than a recreation area located far away from the city, which may require the use of a private car.

The inclusion of a carbon variable into a city's strategy and land-use plans makes climate change issues visible in planning (Lebel et al. 2007; Kalenoja et al. 2008). Estimates of carbon sinks can be compared to total CO_2 emissions of an urban region, and the municipality can aim at both increasing carbon sinks and decreasing CO_2 emissions with proper land-use planning.

Biodiversity, habitats and ecological connections ensuring ecosystem services in urban regions

Ecosystem services are dependent on various aspects of biodiversity, e.g. species diversity and composition, population densities, species interactions, habitat quantity and quality, as well as species mobility between habitats (Lee et al. 2002; Normander et al. 2006). The survival of a species in a given environment depends on several factors, such as the size and isolation of the patch, suitable habitat, and matrix type (Lee et al. 2002). The main reason for local and global species extinctions is the decline and destruction of their habitats (MA 2005). Thus, in land-use planning it is essential to consider how much of each habitat should be conserved in order to maintain certain species or biological diversity in general (Fahrig 2001). Generally, in order to ensure species-level diversity and thus ecosystem services, effort should focus on conserving and restoring habitats (Fahrig 2001). Moreover, the quality of a natural environment is important in land-use planning. For example, in certain conditions only half of the suitable habitat is sufficient for species' survival, if the poor-quality matrix between these habitats is improved (Fahrig 2001). Because of species interactions and the dependence of species on the non-living environment are complex and poorly understood, the preconditions for preserving diversity are not precisely known. As such, it is important to apply the precautionary principle in land-use planning (Deville and Harding 1997).

An example of the impacts of humans on the complex interactions between species is the spread of the tick-transmitted *Borrelia* bacterium studied by Ostfeld and LoGiudice (2003). They showed that the probability of *Borrelia* transmission to humans is lower in large areas with a diverse mammal community. Ticks function as intermediate hosts for the bacterium and get the bacteria when sucking the blood of bacteria-infected small mammals. If an area is large and has a diverse mammalian community, there are both more alternative feeding opportunities for the tick and more predators reducing populations of small mammals, which results in a decrease of the proportion of bacteria-carrying individuals in the tick population. Also in urban regions, large and contiguous green areas with ecological connections are important in maintaining biological diversity and thus ecosystem services (Väre and Rekola 2007). Such biodiversity supporting areas are simultaneously recreation areas for urban inhabitants.

In areas where land-use pressure is considerable, ecosystem services can be secured by leaving green areas in close proximity to one other, so that these areas form larger nature and landscape entities. At the scale of the whole region, such *ecological landscape entities* can consist of forest, nature conservation, Natura 2000 and recreation areas (CEC 1992; Niemelä and Yli-Pelkonen 2008). Colding (2007) used the concept of *ecological land-use complementation*, according to which adjacent ecosystems support and complement each other, resulting in the maintenance of important ecosystem functions and services.

Pollinator insects, for instance, require several habitats, so the spectrum of different habitat types in close proximity benefits such insects. The pollination of plants is an example of how ecosystem services depend on biological diversity (Kremen et al. 2007). Pollination has been classified as a regulating service, which is maintained by pollinators (pollinator insects, birds and mammals), wind and water. Reproduction of seed-producing plants is dependent on pollination, and pollination is crucial for the maintenance of genetic diversity of seed-producing plants. When functioning properly, pollination may be a rather unnoticeable ecosystem service for humans. But if pollinators and thus levels of pollination decline, it may cause considerable ecological and economic disruptions resulting in the decline of agricultural crops, simplification of the genetic diversity of plants, and local extinctions of plant species or populations (Kremen et al. 2007). A decline in pollination can also threaten agricultural areas, parks, gardens and other green areas in cities and urban regions, and thus other pollination-dependent ecosystem services (Nabham and Buchmann 1997).

The principles of ecological land-use complementation are applicable in small urban areas, where it is ecologically advisable to place new public green areas close to existing ones, such as in single house residential areas with gardens. In this way, publicly owned green areas (urban parks etc.) and privately owned green areas (private gardens) complement and support each other ecologically. On the other hand, it is important to place public green spaces also in areas with few other green areas, for example, in densely built housing or industrial areas. It is, however, yet to be investigated how the principles of Colding's (2007) ecological land-use complementation would fit in the planning of urban regions and what kinds of advantages or disadvantages it would have.

In order to secure biodiversity and ecosystem services in urban regions, one has to take into account species movements, i.e. both routes within the built environment and barriers formed by the built environment (buildings, infrastructure, especially wide roads and railways) (Löfvenhaft et al. 2002; Väre and Krisp 2005). An ecological network consists of

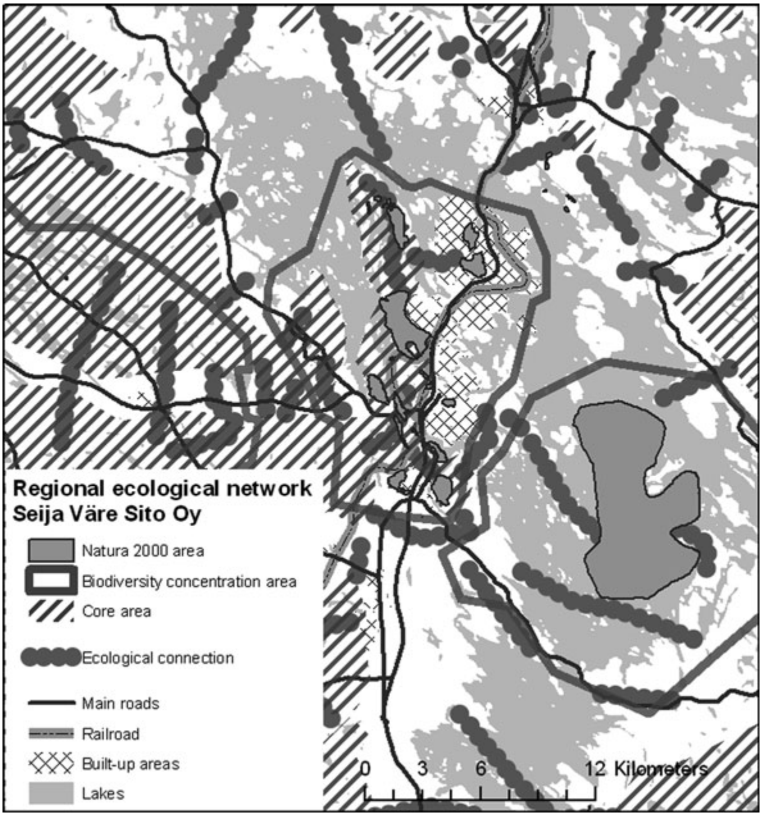

Fig. 2 The location of the city of Kuopio on a cape surrounded by a large body of water is emphasized when addressing the city as part of the regional ecological network. Connections to larger forest areas towards the south and via island chains become important

core areas and ecological connections (Jongman et al. 2004; Bennett and Mulongoy 2006). Core areas are undisturbed and large forest and green areas, or sometimes mosaics constituting agri-forest elements. These areas are important for species and biodiversity. Ecological connections are corridor-like connections of varying width, connecting core areas, or at a smaller scale, different habitats. Thus, maintaining ecosystem services in urban regions calls for both local and regional level ecological networks. As an example, the ecological network of the Kuopio region in east Finland is presented (Fig. 2). According to Väre and Rekola (2007), creating an ecological network should have the same weight in land-use planning as important ground water areas, landscape structure, and recreation area networks. At best, ecological connections serve both animal and human movements. They are associated with values related, e.g. to biological diversity, cultural history, recreation and education (Väre and Krisp 2005; Bryant 2006). Moreover, ecological connections or, correspondingly, different barrier effects can be significant in the circulation of nutrients and water (Ahern 2004).

Different views on the significance and effectiveness of ecological connections exist. Critical comments have been presented, for instance, on whether ecological corridors function as effective routes for species, whether connections distract attention from conserving habitats and nature conservation areas, whether the planning of connections is too much concentrated on forest corridors, and how the connections can be ensured in different land ownership circumstances (Simberloff et al. 1992; Bryant 2006). Several studies have, however, concluded that with ecological connections an area's total species richness increased (Debinski and Holt 2000; Damschen et al. 2006; Kettunen et al. 2007), which can be considered an argument in favour of planning connections in urban areas. Furthermore, preserving ecological connections is important because they may turn out to be useful even if current research information is contradictory, i.e. the precautionary principle is advisable (Niemelä 2001).

Effects of climate change on ecosystem services in urban regions

Climate change is a significant threat to biological diversity (Pöyry and Toivonen 2005; Araújo et al. 2006; Scholze et al. 2006). Diseases, pests and drought may increase, sea water level may rise, and seasonal climatic patterns may change dramatically (IPCC 2007). Already observed gradual changes reveal the vulnerability of ecosystems (Durant et al. 2007; Opdam and Wascher 2004; Thorup et al. 2007).

These changes will have impacts on ecosystem structures, functions, the spatial distributions of species and on ecological resilience, and thus affect ecosystem services of urban areas (Marttila et al. 2005; Schröter et al. 2005). It is likely that the effects of climate change will be similar in cities around the world, such as increased urban heat island effects, risks in flood security, deterioration of air quality and problems caused by alien species (Wilby and Perry 2006). Uncertainty in predicting the effects of climate change also affects the evaluation of the future development of urban regions (Peltonen et al. 2005).

Due to risk of climate change-induced sea level rises, housing construction in coastal areas in Finland has been restricted so that the foundations of buildings must be at least 3 m above the present sea level (Ympäristöministeriö 2008). When shorelines have to be elevated by embankments, pressures of efficient land use increases and free-access shores in a natural state will diminish.

Preparing for local flooding in built-up areas caused by heavy rains has to include expensive storm water management systems with pipelines and pumping stations (Setälä et al. 2009). The management of storm waters drained from roofs and hard surfaces also has an impact on land-use planning, and flooding and storm water drainage areas have to be considered in detailed planning.

Using the ecosystem services concept in land-use planning

The concept of ecosystem services, associated with urban regions in Finland, has been so far mainly used for research purposes. Therefore, the familiarity and use of the concept in land-use planning was studied by interviewing 24 professionals involved in land-use planning and environmental administration in Southern and Central Finland. Only a third of the interviewees were familiar with the ecosystem services concept, but half of those who were not familiar with the concept, said they understood the concept after discussing it during the interview (Yli-Pelkonen, unpublished).

During the same interviews, the interviewees were asked to give their opinions on the applicability of the ecosystem services concept in urban conditions. Some of the

Table 3 Interviewees' opinions on the applicability, advantages, challenges and disadvantages of the ecosystem services concept in land-use planning in urban areas

Ecosystem services concept	Opinions of the interviewed actors in planning and environmental administration
Advantages	With the concept it may be easier to explain the benefits of conserving green areas and areas in a natural state to employees of cities and municipalities
	The concept may provide a better possibility to address ecological issues, also from the perspective of economics and service production
	With the concept it may be possible to determine a monetary value in compensatory situations related to nature issues
	The concept could help in explaining why it is important to use green areas to absorb stormwater
	The concept could provide a broader framework for contemplation on how the inhabitants of built-up areas would benefit from conserving green areas
	The concept could help in conserving such nature that does not have threatened or endangered habitats or species
	Using the concept in urban areas could enhance the understanding between planners and inhabitants on ecosystems and their functioning
Challenges or disadvantages	The concept appears to be clumsy and difficult for practical use
	The concept does not necessarily provide anything new, because the same matters are included in the principles of sustainable land-use planning or considering nature values
	The concept may produce an attitude in which nature is only seen as a service for humans, nature values are being exposed to economic thinking or nature is seen from an entirely utilitarian point of view
	The concept is unfamiliar and the word *service* may cause confusion with regards to other services (e.g. services provided by the Finnish Forest and Park Services, social and health services)
	It may be very difficult to measure ecosystem services financially
	Many people may have difficulties in understanding the concept *ecosystems*

advantages, challenges, and disadvantages of the concept that came up in the interviews are presented in Table 3.

These interviews illustrate that the concept *ecosystem services* is new and unfamiliar to many actors in urban land-use planning, although the issues contained in the concept have been included in land-use planning principles based on sustainable development. However, the interviewees assigned several benefits to the concept.

For instance, the concept could help in explaining how the conservation of a forest including threatened species can bring more value to the neighbourhood in the form of cultural ecosystem services or how conservation could be experienced as an opportunity to build uniqueness or identity of an area, instead of seeing conservation as a threat to urban development. Introducing the concept could help in promoting the development of a more comprehensive understanding of ecosystem services in the minds of both civil servants and decision makers, as well as inhabitants. Such understanding of, for example, considering the whole city as an ecosystem or a combination of ecosystems could promote the comprehension of, e.g. the importance of unsealed green areas in storm water absorption (Setälä et al. 2009). The ecosystem services concept could also help emphasise the importance of those green areas that do not contain threatened or endangered elements for the functioning of broader ecosystems or the physical and psychological well-being of urban dwellers.

Another advantage of the ecosystem services concept is that nature issues can be addressed from the perspective of economics and service production. However, this is also seen as a disadvantage, as many interviewees considered that there is a risk that nature will merely be transformed to a service for humans and to a human-centred product. Thus, before the *ecosystem services* concept can be used by civil servants and urban inhabitants it is important to consider how the concept is perceived to avoid misunderstanding.

It is also expected that financial compensation values can be derived from the *ecosystem services* concept, but the task is challenging. There are only a handful of attempts in assigning financial values to different ecosystem services in urban areas (e.g. Hougner et al. 2006; Philadelphia Parks Alliance 2008), although the body of literature on this matter is growing (Daily and Matson 2008).

The Finnish word for *services* was criticized and the interviewees suggested other words to replace it, even though none thought that they had found a better expression for the concept. The *ecosystem services* concept has the potential to assist and inform land-use planners, although it is debatable whether the negative stigma associated with the word *services* will stay with the concept.

Future challenges and potential of urban ecosystem services

The Ecosystem services approach provides an opportunity for land-use planning to develop ecologically sustainable urban regions. This is because the general definition of urban regions encompasses the functioning of humans and society, and human activities (using a service or benefiting from it) are an essential part of the ecosystem services definition. Moreover, ecosystem services are a functional link between humans and nature.

It is important to consider the interactions between different ecosystem services and land-use planning in urban regions, which are strongly modified by human actions. A comprehensive and integrative ecosystem services approach provides opportunities for taking goals of sustainable development into account in land-use planning, but as the interview study has shown, ecosystem services are not yet much discussed among land-use planning professionals. Currently, the concept is seen as abstract and too complex for practical planning. Therefore, it is important that information on ecological processes enabling ecosystem services is included in land-use planning and that research information and new concepts are taken into account in decision making. Discussions on prioritizing different ecosystem services will, hopefully, clarify both the information basis of decision making and its impacts on decision makers and urban residents.

Climate change is one of the most significant threats to the conservation of ecosystem services. Another considerable threat is the change in land-use and land-cover (MA 2005), which may well, in the short term (e.g. 10–30 years), be a larger threat to biological diversity and ecosystem services than climate change (e.g. Grimm et al. 2008). Both of these threats can be mitigated by land-use planning. In cities and urban regions, this often means consolidating urban community structure so that transportation needs decrease (Lerch 2007) and habitats remain contiguous resulting in decreased CO_2 emissions. The challenge is to build in a compact way, and at the same time maintain local nature and important ecosystem services, such as recreational services, storm water absorption and carbon sinks (Tratalos et al. 2007). With good planning the negative impacts of urban development on ecosystem services can be diminished (Whitford et al. 2001).

Currently, information on ecosystem services of urban regions is lacking and there is a need to improve the knowledge base for land-use planning. One of the essential questions is how different planning options of urban regions, their impacts and uncertainties can be addressed for future climatic and other scenarios. A scenario model based on geographical information systems and population forecasts, has been developed (Hansen 2007), and the model has been tested in different parts of Scandinavia (Hansen 2007; Hallin-Pihlatie and Hansen 2007). In follow-up studies there is a need to determine how the impacts of land-use change on ecosystem services can be incorporated into such a model. Finland's Strategy for Biological Diversity and Sustainable Use of Nature in 2006–2016 (Heikkinen 2007) emphasizes an improved knowledge base, so that goals of protecting and maintaining biological diversity can be achieved. Regarding ecosystem services of urban regions, it is important to invest not only in studying ecosystem services, but also in studying uncertainties in planning and implementation.

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