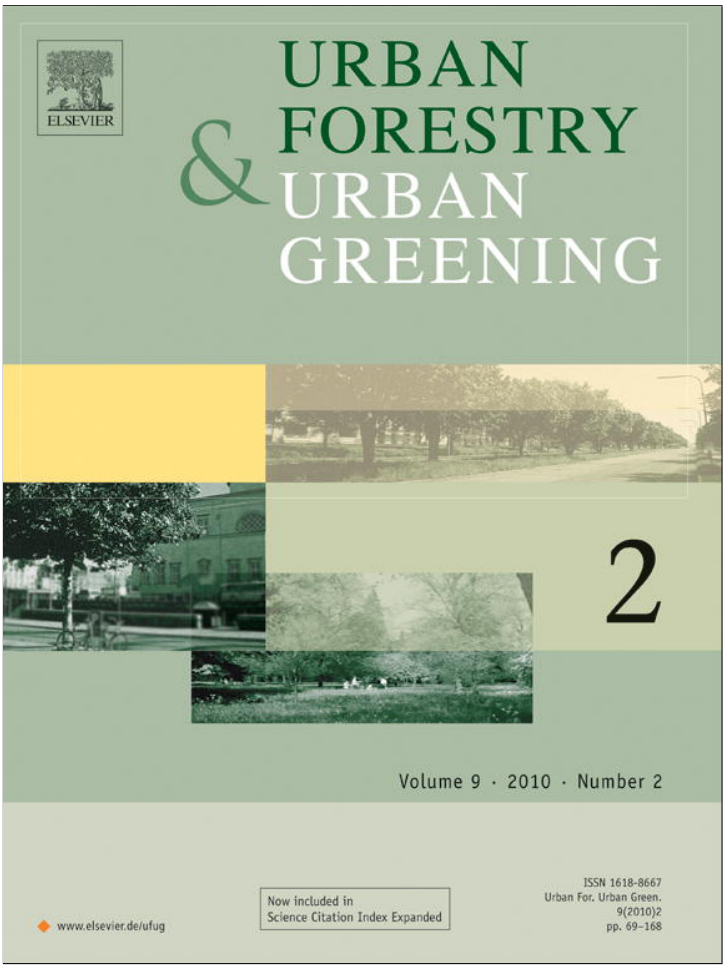

Urban Forestry & Urban Greening 9 (2010) 101–112

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.de/ufug

Recreational mapping and planning for enlargement of the green structure in greater Copenhagen

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ARTICLE INFO

Keywords:
GIS
Green structure planning
Recreational experience mapping
Regional recreational planning

ABSTRACT

Since 1947, the development of greater Copenhagen has followed a plan that divided the city into a centre and five urban 'fingers'. The 'Finger Plan' has constituted an important part of the planning framework, albeit informally. Under this plan, four green wedges and three green rings, located between the urban 'fingers', form a multifunctional recreational landscape of high value to the citizens. In 2006, the Greater Copenhagen Authority put forward a proposal for the enlargement of the existing green wedges and the addition of a new fourth green ring. In order to achieve this plan, detailed mapping of recreational opportunities was needed. Based on existing planning approaches combined with theoretical and empirical studies on preferences, use, and composition of green spaces, a method for monitoring and analyzing recreational experiences using seven specific categories was adapted and further developed to Danish conditions and applied to land use categories in greater Copenhagen. Areas that comprised one or more recreational experience values were designated by use of GIS techniques and map-based indicators for each of the seven 'experience classes' (wilderness; feeling of the forest; panoramic views, water, and scenery; biodiversity and land form; cultural history; activity and challenge; service and gathering). For incorporation into the regional and municipal planning policy, the seven experience classes were transformed into GIS, creating a decision support system for use at municipal and regional levels in order to facilitate future planning of the recreational landscape in greater Copenhagen. The method proved capable of pointing out important areas for recreational development in the enlarged but not yet developed areas. Further, the division of the recreational potential into seven classes makes possible site-specific development that utilizes existing potential.

Introduction

After a period of recession during the late 1980s and early 1990s, greater Copenhagen has experienced rapid growth over the last decade (Andersen et al., 2002). More houses and more growth in the tertiary sector characterise the development and there has been significant growth within specific industries (such as biotechnology, pharmaceuticals, telecommunication, information technology, advanced food processing, and tourism). Between 1994 and 2002, greater Copenhagen acquired 107,000 new workplaces (Hartoft-Nielsen, 2007). The population in the region, approximately 1.85 million (2007), is growing, with an additional 100,000 persons expected to be added over the next 10 years (HUR, 2005). The turnaround from recession to growth is a consequence of a positive economic trends combined with specific governmental decisions, such as the completion of the bridge to Sweden in 2000. However, Copenhagen's economic renaissance is also a result of the ongoing process of globalisation, in which Copenhagen's location between northern Scandinavia and central Europe, along with excellent accessibility and a well-educated labour force, has made the region attractive to both national and international companies (Hansen and Serin, 2007; Hartoft-Nielsen, 2007). Hence, greater Copenhagen constitutes a central part of the newly emerging Øresund (Sound) region, comprising the Danish island of Zealand (which includes Copenhagen on the eastern coast), Southern Sweden (with the city of Malmo on the western coast), and the island of Bornholm, off the Swedish southern coast. In 1994, the Swedish and Danish prime ministers initiated a transnational environmental program and declared that the Sound region shall be among the leading regions in Europe with regard to environmental protection. The region was also promoted for its multitude of amenities in the field of nature and outdoor recreation (Öresundskommiteen, 1998, 2000). This promotion has continued, and in 2006 the greater Copenhagen Authority (GCA) was continuing to promote the Sound region for its low level of pollution, large number of green areas, easy access to the countryside and nature areas, costal location, and large numbers of leisure and recreational

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1618-8667/$ - see front matter © 2010 Published by Elsevier GmbH.
doi:10.1016/j.ufug.2009.06.007

facilities (HUR, 2006). Promotion of environmental and recreational qualities relating to the region is based on the urban and green structure of the region, and reflects the outcome of a regional planning process that commenced as early as 1947. Despite the fact that the proposed planning measures have been implemented with different degrees of success and effectiveness during the last six decades, many of the original intentions from the first modern city plans of greater Copenhagen have been implemented; hence they have now become defining features of the urban structure of the region (Andersen et al., 2002; Hartoft-Nielsen, 2007).

Expectations as to future expansion and internal promotion of the region encourage coordinated and well-defined planning measures in order to remain competitive with other Danish and Northern European regions. However, the former planning frame has undergone a change with the reform of the local government structure in 2007. Under this reform, the regional institutional bodies in Denmark, including GCA, were abolished. Spatial planning in greater Copenhagen is now divided between the state and the 34 municipalities within the region, giving the municipalities new authority as regards spatial planning and land management. As a consequence of this development, in 2007, GCA presented a vision for a future green structure (HUR, 2006) that would maintain the positive relationship between the urban areas and the green structure of greater Copenhagen. This vision focuses on an enlargement of the existing green structure and the future development of recreational and leisure facilities in the enlarged areas, as illustrated in Fig. 1. The vision also includes a focus on issues such as sustainability, stewardship, and management of existing landscape and nature values in order to ensure that the future recreational landscape comprises the needed recreational experiences scaled from developed facilities to more untouched nature and wildlife experiences in the countryside.

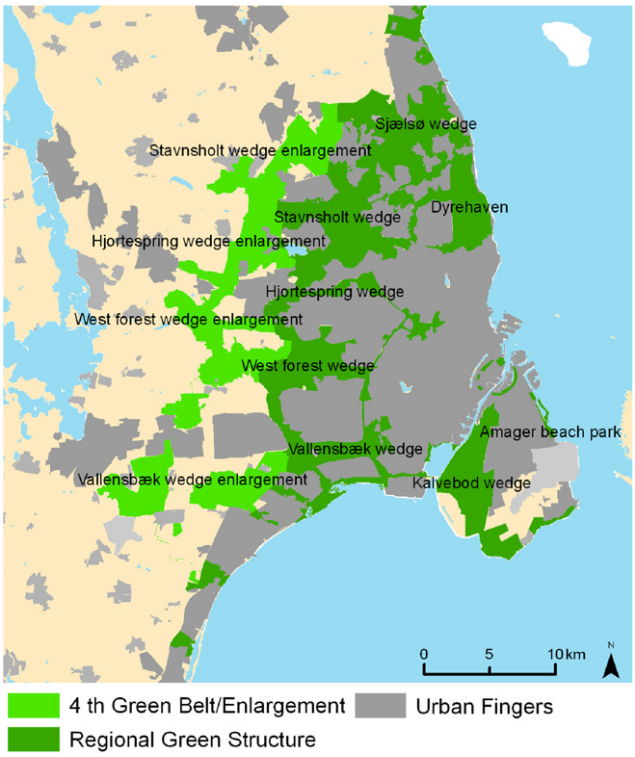

Fig. 1. Regional green structure of greater Copenhagen, Denmark. The urban fingers are separated by green structures defined as green wedges that mainly have an urban recreational purpose.

Objective

As a consequence of the vision for a future green structure, which proposed an enlargement of the existing green recreational structure, there has emerged a need for a diverse regional mapping of the recreational resources in greater Copenhagen. A detailed overview and inventory of the green structure was needed in order to focus on the future development of recreational experiences and to investigate the recreational potential of the areas intended for the future green structure enlargement. Within the framework of the EU Interreg project, *The Landscape as Resource*, GCA and Forest and Landscape Denmark began to cooperate in efforts to obtain a regional overview that could enhance the knowledge base required for the future enlargement.

Based on the close dialogue with the regional planners three objectives were defined:

1. to enhance the existing knowledge by creating an overview of the existing opportunities of recreational experiences of the present green structure,
2. to develop an overview of the recreational potential of the future enlargement areas,
3. to investigate the extent to which existing geo-information and GIS technology can facilitate recreational planning and overview at regional and local scales.

The idea was to develop an expert tool for improving the knowledge base for recreation planning. Early on in the process, a desire was expressed by GCA that the assessment be operational in GIS. A GIS provides good opportunities for a systematic and transparent mapping procedure of a large region while at the same time retaining local nuances and details in the mapping work at local levels.

The aim of improving the existing recreational planning basis also reflected the more general desire to improve the link between health policy making and outdoor recreation by promoting recreation resources across sectors in spatial planning.

Assessment of recreational values

The development of greater Copenhagen has followed a proposed master plan from 1947 that became known as the 'Finger Plan'. Hence, greater Copenhagen is characterised as a star city, similar to Stockholm, Helsinki, and Hamburg (HUR, 2006). However, due to Copenhagen's location on the Oresund Strait between Denmark and Sweden, the urban structure within the region has the pattern of a hand that includes a central 'palm' from which extend five urban 'fingers' into the hinterland. Today, some of these fingers extend approximately 40 km outside the city. The plan from 1947 also proposed a green structure based on developing the countryside between the urban fingers so that it would include recreational and leisure areas beside more traditional farmland and greenery. The development of recreational values within the green structure of greater Copenhagen has been an ongoing process, parallel to the development of the finger structure (Caspersen et al., 2006). The awareness of providing easy accessibility to green areas was present in the 1947 plan (Egnsplankontoret, 1947), although an explicit recognition of the interrelation between health (absence of mental fatigue, stress) and visits to nature and green areas was not expressed. Since 1947, this acknowledgement has been one of the important arguments for the development of the star-shaped city plan. Accessibility to green areas during the last decade has become a topic of increasing research interest, and studies of

greater Copenhagen have documented an increasing trend towards new demands for housing in green surroundings (Kristensen and Præstholm, 2004; Busck et al., 2006). The importance of access to green areas is illustrated by Matsuoka and Kaplan (2008), who surveyed 90 articles on human interaction with outdoor urban environments and found strong support for the important role played by nearby green environments in ensuring human well-being. Distance to green areas determines how frequently they are used, and both Danish and international research have shown a negative association between the distance and the number of visits to nature and other green areas (Jensen and Skov-Petersen, 2002; Grahn and Stigsdotter, 2003; Hansen-Møller and Oustrup, 2004; Jensen and Koch, 2004; Tyrväinen et al., 2005). Moreover, it is known that people living in large urban areas with the longest distance to green areas have higher probability of increased stress levels (Nielsen and Hansen, 2006). Kaplan and Kaplan (1989) claimed that access to natural landscapes would provide better means for restoration, and these findings have been supplemented by research that stresses this interrelation. Velarde et al. (2007), reviewing over 100 articles, found 31 which provided evidence of health effects of landscape views. The main health effects identified were "reduced stress, improved attention capacity, facilitation recovery from illness, amelioration of physical well-being in elderly people, and behavioural changes that improve mood and general well-being" (ibid. p. 210). Hartig et al. (2003) focused on the physical effects related to visits to and exercise in natural environment and showed that when compared with walking in urban settings, walking in a nature reserve resulted in changes in blood pressure that indicated greater stress reduction. Other positive health effects are related to health benefits of exercise and social contacts (Van den Berg et al., 2007). In a survey of 421 persons in Eastern Helsinki, Tyrväinen et al. (2007) found that the most frequently identified positive values with respect to green areas were 'opportunities for activity' and 'beautiful landscape'; also rated highly were 'freedom and space', ' a feeling of forest', and 'peace and quiet'. The research indicates that access to nearby green areas is important and that the use of the urban and peri-urban green areas is diverse and multifunctional; hence, the areas have to comply with many different forms of recreational uses. A method for creating an overview and mapping of the recreational potential has to be diverse and multifaceted in order for the planning to be effectively utilized.

Approaches for mapping of recreational experiences

During the 1970s, a method for mapping recreational experiences, complying with the demand for a more comprehensive qualitative background data for recreational planning measures, was developed in the United States. The Recreational Opportunity Spectrum classification system (ROS) divides the possible recreational experiences into a spectrum of experiences consisting of different classes, starting with 'wilderness' and proceeding towards more anthropocentric-dominated classes. It thus creates a spectrum of possible recreational experiences (Driver et al., 1987). Each class has been defined in terms of characteristic activities and settings and probable experience outcomes. Experiences are viewed within the context of motivation theory, meaning that the recreation experience is defined as the package or bundle of psychological outcomes (e.g., stress relief) desired from a recreation engagement (e.g., walking in a forest; Manfredo et al., 1996). The dimensions of people's recreation experiences are known as a Recreational Experience Preference (REP) scales. The REP scales are considered to be relatively stable, basic human characteristics (Manfredo et al., 1996). The classification system has been made operational by various public agencies, e.g., USDA Forest Service (USDA, 1982), by an emphasis on settings in each class expressed with the help of indicators; the mapping of these indicators is intended to facilitate the management of expected recreational experiences. The system has been criticized for being too simplistic (Kaplan and Kaplan, 1989), and Driver et al. (1987) argue that the relationship hypothesized among settings, activities, and expected experiences is viewed probabilistically. The ROS system is a rationalistic planning approach based on rationalistic behaviour from the recreationist, geared for planning by a simplistic focusing on manageable settings.

The realization of desired and expected experiences is linked to personal preferences and perceptions. All human senses are in use, although some human senses are naturally more developed than others. For example, visual perception is very important for most humans (Kaplan and Kaplan, 1989; Bell, 1999). In our perception of our surroundings, we also project our feelings and preconceptions onto it; this is why landscapes or wilderness are as much a state of mind as they are physical entities (Bell, 1999).

An approach inspired by the ROS system was developed by Grahn and Sorte (1985) at the Swedish Agricultural University. They divided the possible recreational experiences into eight classes based on the idea of thematic experiences, using a scale from 'untouched' and 'nature-oriented' experiences to classes dominated by an anthropocentric use as places for gathering and festivities, and culture (Grahn, 1991). The method has been successfully used in different cities in southern Sweden, creating a more diverse understanding of the possible recreational experiences relating to different green urban areas (Grahn, 1991; Grahn and Berggren-Bärring, 1995; Grahn et al., 2004). While feasible for use in classifying smaller areas such as parks, the method was not intended for regional use and did not comply with the specific demands that relate to this larger scale, i.e. limits on field work, type and use of indicators, etc. Hence, in 2004, the Stockholm Regional Authority (Regionplane och Trafikkontoret RTK, 2004), produced a set of maps for 10 green wedges in Stockholm based on a method for GIS mapping of recreational experiences and social values. The approach was developed for regional use; the eight classes was reduced to seven and slightly changed, while quantitative indicators were formulated so as to make the method easier to apply at regional level. As with the former method by Grahn and Sorte (1985), the recreational experiences are treated as social values considered from a human perception of the green structure and as such, are expected to provide a more comprehensive background for future management of the green structure. The classes were tested by in depth interview of 24 persons, which was used to refine the seven classes.

Method

A Danish method for mapping of recreational experiences

The mapping approach of the seven recreation experience classes from Stockholm was discussed with experts from Stockholm and planners from GCA. Based on these discussions and on the existing documentation, it was decided to adapt the method and develop it further for use in a Danish context.

In the last 30 years, multiple Danish representative studies (surveys) have revealed recreational preferences concerning choice of recreation environment, recreational activities, and motives for recreation (Koch and Jensen, 1988; Jensen, 1998, 1999; Kaae and Madsen, 2003; Jensen and Koch, 1997, 2004; Nielsen and Hansen, 2006). In connection with more detailed interview studies (e.g., Hansen-Møller and Oustrup, 2004), research findings have revealed recreation preferences for the

Table 1
Description of the seven experience classes converted to a Danish context based on Danish research findings.

Experience class	Description
1. *Wilderness*	In old growth forest, nature forest, and forest swamps, trees are often gnarled, twisted, and old; and the possibilities of encountering dead wood and dying trees are high. Such locations provide ample opportunities to experience a serene, undisturbed and untouched environment together with silence (the absence of urban derived noises and the sounds of nature)
2. *Feeling of forest*	In compact forest areas, it is possible to experience the feeling of being away (stepping into another world), a world where one can experience sounds, lights, and smells of the forest together with peacefulness and silence. In older forests, branches and leaves form a canopy, which enhances the feeling of the forest as a special environment
3. *Panoramic views, water, and scenery*	Locations with good viewing opportunities facilitate experiences of wide space and freedom. Hilltops, open landscapes, lake- and sea shores are examples of such locations
4. *Biodiversity and land form*	Areas with high biodiversity enhance the changes for encountering flora and fauna, and stimulate feelings of mutual connection, exploration, and curiosity. Landscapes with an easily recognizable geomorphologic formation (such as hummocky moraine or tunnel valleys) enhance the opportunities for deeper understanding of the coherence of nature and the link between biodiversity and land form
5. *Cultural history*	The landscape consists of multiple traces of cultural historical heritage. An area with tangible heritage (physical historical evidence) in the form of human-made structures and areas with intangible heritage (e.g. settings of historical events) promotes feelings of time depth and belonging
6. *Activity and challenge*	Specific areas and facilities support possibilities of physical activity in the landscape. Golf courts, different tracks, and routes are examples of facilities enhancing opportunities for physical challenging nature, oneself, or others in natural surroundings
7. *Service and gathering*	Feelings of safety, security, and confidence in nature are important for some people in order to enjoy a nature experience. Services like parking lots, information through signing or audio-guiding, bonfires, and table and bench sets promote the feeling of safety. The same facilities also generate settings enhancing social gatherings and recreation with family or friends

Danish population in general and specifically for the urban population of greater Copenhagen. The multiple Danish surveys serve as a large and detailed data pool on outdoor recreation in Denmark. The results and data from the surveys were already available; thus, it was decided not to carry out any new questionnaire surveys on preferences and recreation behaviour in greater Copenhagen.

The Danish findings were transferred to the conceptual framework constituted by the seven experience values used in the Swedish method, and this result was further converted into a mapping approach that fitted Danish conditions. The seven experience classes are briefly outlined in Table 1.

The ROS planning frame and the use of REP scales have inspired Danish recreation research as well as the Swedish approaches for mapping of recreation experiences. The seven different classes represent a spectrum of multiple motives for outdoor recreation or a spectrum of desired recreation experiences. Several Danish studies mentioned above have surveyed motivations for nature visits based on the REP scales developed in the United States. The seven classes in Table 1 are in line with the main motivation domains revealed by Jensen (1998) and Kaae and Madsen (2003).

The above-mentioned Danish studies support 'wilderness' and 'feeling of forest' as mapping objects (see Table 1). Serene, peaceful, and silent nature experiences are among the highest rated recreational preferences, and forest (particularly older broadleaved forest without understory), are the most preferred recreation environment (Jensen, 1999; Jensen and Koch, 2004). These special features of forest are especially popular with the urban population in larger cities, where forests serve as a refuge for 'recharging our batteries', purification, and renewal (Hansen-Møller and Oustrup, 2004). The third experience class is named 'panoramic views, water, and scenery'. Preferences for visiting viewing points, lakes, and coastline are well supported in Danish recreation research (e.g., Jensen, 1998; Kaae and Madsen, 2003) as well as in international research on preference and perception of water in landscapes (e.g., Kaplan and Kaplan, 1989; Appleton, 1996). The experience of 'biodiversity' is more complex and expert knowledge and additionally information might be needed in order to fully comprehend and experience settings rich in biodiversity. However, studies have shown a general compliance between biodiversity in landscape and preference for landscape (e.g., Nassauer, 2004; Junker and Buchecker, 2008). 'Cultural history' as a motive for recreation has so far been relatively neglected in Danish recreation research. Jensen (1998) comments that visit to (pre)historical monuments (e.g., burial mounds, cairn) are seldom the main purpose of a nature experience; they are often combined with visits to other nature types. Cultural history might play an important part in the high rating of 'enjoyment of landscape' as the main motive for recreation in nature settings.

The two final classes, physical activity and social gatherings, concern relatively well-known and required recreation experiences: using nature for exercise and using nature for social gathering. 'Activity and challenge' covers a broad field of activity-oriented experience in nature, from walking the dog to hiking, mountain biking, and horseback riding, as summarized by Jensen and Koch (2004), while 'service and gathering' is based on motives for outdoor recreation as socializing with others (Jensen, 1998; Kaae and Madsen, 2003).

Data and GIS indicators

In order for the planning method to be viable in green structure planning, a methodologically transparent approach was needed. This was achieved by the elaboration of quantitative and distinctive map indicators. To ensure that the mapping method was applicable on a regional scale, and yet still included a level of detail that made it useful for municipality-based planning, it was decided to use digital maps and GIS as the principle data analysis tools in correspondence to the objectives from GCA case officers. Additionally, the formulation of experience classes and choice of mapping data were adapted to the land use and landscape composition in greater Copenhagen: approximately 47% agriculture, 13% forest (of which 55% is state forest), 4% lakes, and 600 km coastline. Due to this composition, the planning method has a relatively large emphasis on countryside and coastline aspects in assigning the indicators. Combined with the relative large area to be mapped (approximately 1300 km^2), we developed a relatively data-driven mapping approach. The method utilizes the fact that modern digital maps consist of separate and individual map objects as points, lines, or polygons. This enables us to generate user-defined maps because the individual landscape element and map object can be copied separately and combined into another user-defined thematic map within each of the seven classes.

Table 2
Methodological overview of mapping indicators for each of the seven experience values.

Experience class	Map-based indicator	Elaboration, GIS criteria (data source[a])
1. *Wilderness*	Nature forest	National designation (SA)
	Forest swamp	Overlay of tree cover and wet areas (GA)
	Old growth deciduous forest	Minimum 200 years (GA)
	Old growth coniferous forest	Minimum 100 years (GA)
	Silent area	Maximum 45 dB(A) traffic noise from road, rail, air (SA, CD)
	Minimum distance to urban land use	Bufferzone 250 m (GA)
	Minimum distance to high-voltage line	Bufferzone 75 m (GA)
2. *Feeling of forest*	Compact forest	Minimum 5 ha, 50 m inside buffer (GA)
	Deciduous forest	Minimum 40 years (GA)
	Coniferous forest	Minimum 50 years (GA)
	Silent area	Maximum 55 dB(A) traffic noise from road, rail, air (SA, CD)
	Minimum distance to high-voltage line	Bufferzone 75 m (GA)
3. *Panoramic views, water, and scenery*	Hill top with viewing potential	Analysis based on digital terrain model and more (GA)
	Lake- and sea shore	Buffer analysis (GA)
	Lake and sea surface	Minimum 6 ha (GA)
	Coherent open landscape	Minimum 6 ha (GA)
	Silent area	Maximum 55 dB(A) traffic noise from road, rail, air (SA, CD)
4. *Biodiversity and land form*	Wood edge and lake shore	Bufferzone 25 m (GA)
	National nature protection area	Bog, marsh, moor, and meadow, all minimum 0.25 ha, ponds min. 0.1 ha, and most streams (CD)
	International nature protection area	Natura 2000 designation (SA)
	Distinctive geomorphologic feature	Esker, moraine, hummocky, tunnel valley, and more (SA)
	Geological hot spot	Gravel pit, coast slops, boulder, and more (SA, CD)
5. *Cultural history*	Cultural historical building	Manor, windmill, watermill, protected farms, and more (SA)
	Well-preserved village	Regional assessment and designation (CD)
	Barrow	Burial mound, cairn (CD)
	Dike	Stone dike and earth walls (CD)
	Historical path	Closed railway line, road with historical significance (CD)
	Cultural environment	Designation on county level (CD)
	Cultural historical land use type	Meadow, pasture, grazing forest (SA, CD)
6. *Activity and challenge*	Intensive activity area	Golf court, urban green areas, football field, and more (CD)
	Intensive activity location	Outdoor swimming, nature playground, camp site (SA, CD)
	Footpaths and tracks	Walking paths in urban, open, and forested areas (SA, CD)
	Routes and other paths	Route and paths for biking and horseback riding (CD, SA)
	Waterways, lakes, and sea	Kayaking, canoeing, sailing allowed (SA, CD)
7. *Service and gathering*	Accessibility facility	Parking area, bus and train stop (CD)
	Communication facility	Information sign, tourist office, nature exhibition, visitors farm, nature school (SA, CD)
	Security facility	Camp fire, bird tower, beach, lifeguard, toilet, tea garden, table and bench set (SA, CD)
	Accommodation facility	Camp site, camping ground, B&B, hostel, hotel (SA)

The map-based indicator consists of map themes that form the experience class. The GIS criteria are the specific settings of the individual map theme chosen for the particularly experience class.

[a] County Designation (CD), State Agencies (SAs), GIS Analysis (GA).

A key element in the development was the objective of maintaining a high level of transparency in the process of designation and mapping, in order to reduce subjective decisions, which create fuzziness in the process. This was sustained by defining a set of criteria for each map-based indicator.

The indicators for each class are shown in Table 2. More than 15 different topographic and thematic datasets contributed to the final mapping result. A 1:10,000 vector dataset from The National Survey and Cadastre (Kort & Matrikelstyrelsen) served as the main data source. The database was supplemented by geodata from regional spatial planning and national authorities together with geocoding of different register-based data.

An elaboration of the possible GIS-based criteria (Table 2) was needed in order to designate each of the seven experience classes. The criteria were defined in order to focus the specific experience class and to make the mapping easy to distinguish from neighbour classes. The definition of the different criteria is related to the Swedish experiences from Stockholm (RTK, 2001, 2004) but they have been correlated with findings from the Danish preference studies (Jensen, 1998, 1999). The mapping indicators consist of three types. The first includes indicators focusing mainly on visual perception. Examples are landscape elements and landscape surroundings, which increase the probability of realising the expected recreation experiences. The second type includes audiovisual features incorporated by the use of indicators of different levels of noise nuisance potentially disturbing visual nature experiences. Finally, indicators of functional services like different recreation facilities are incorporated.

As summarized in Table 2, the first two classes, 'wilderness' and 'feeling of the forest', are mapped mainly through GIS analyses based on the national 1:10,000 vector dataset and the digital 1:10,000 State Forest vector dataset. The criteria that relate to 'wilderness' and 'feeling of forest' are based on data that include species and age as a parameter and noise. Nature forest is designated only in state-owned forest areas, so as to comply with the wilderness definition in Table 1. The designation of wilderness was decided to include age parameters. The selection of forest age classes is most restrictive with regard to class 1 because a relatively high age is considered as an important factor for the experience of an untouched environment that relates to this class. In Denmark, deciduous trees are normally cut before they are 200 years old and coniferous before 100 years; so trees older than 100 or 200 years indicate old growth forest. Both classes include a minimum distance at 75 m to power lines, which corresponds to the forest clearing zone around power lines.

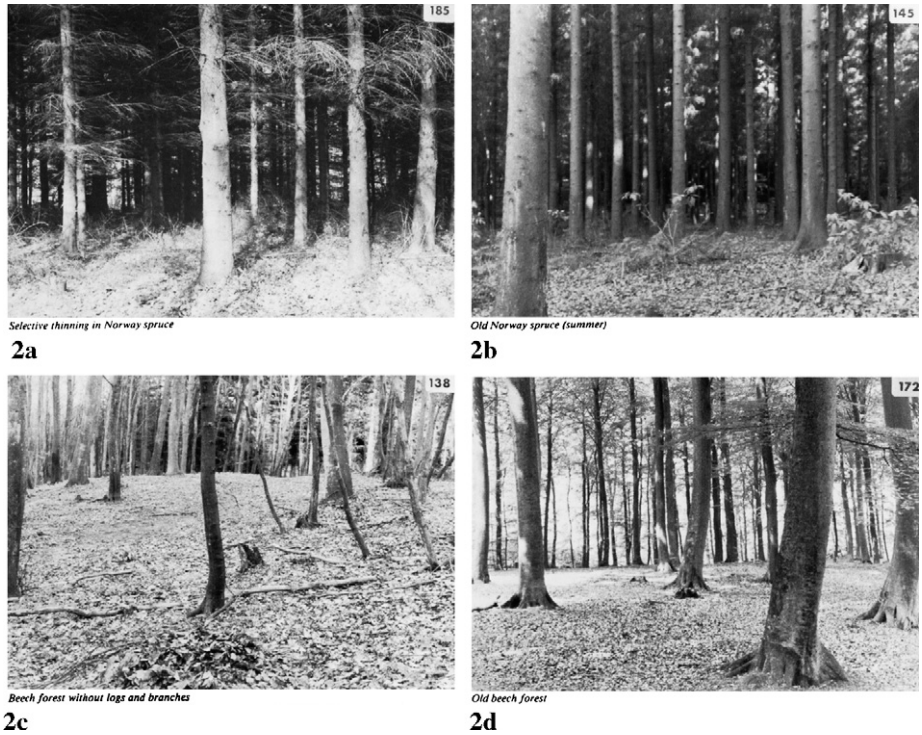

Fig. 2. Different degrees of openness due to understory differences are demonstrated by the two figures of coniferous age groups at 25 (Fig. 2a) and 49 years age (Fig. 2b). The age criterion at 50 years is set to ensure the degree of openness that visitors tend to find the most preferable. Both young (Fig. 2c) and old stands (Fig. 2d) of beech rank higher in preference than young, respectively, old stands of coniferous. Pictures and preference results from Koch and Jensen (1988).

The minimum age criterion for the specific forest stands is based on the fact that Danes prefer old forest without understory (Jensen, 1999). Particularly, coniferous forest must have a relatively old age in order to create a certain degree of openness that stimulates this experience. Based on field surveys, this openness exist at approximately 40 years of age for deciduous forests and 50 years for coniferous forests as illustrated in Fig. 2.

This class 'feeling of forest' also includes criteria as an inside forest buffer at 50 m. This criterion is meant to facilitate the experience because it secures that the visitor will be surrounded by trees.

The designation of class 3 'panoramic views, water, and scenery' includes that a given area that otherwise fulfils the demands for designation must also have a certain size to promote the experience. Based on field surveys, an area size of approximate 6 ha was selected as a criterion for designation. It complies with the fact that areas in this class must have a relatively large size in order to be experienced as having panorama and scenery. The 'biodiversity and landform' was mapped largely by the use of existing public designations carried out on county level in conjunction with the National Planning Act and the Nature Protection Legislation; however emphasis is also put on the designation of elements as hedgerow and especially boundary zones as edge of a wood due to the relatively high biodiversity that typical exists in these zones (Forman, 1997). Class 5 'cultural history' consists of specific historical elements that are easily distinguished but it also includes regional assessment and designations on county level that are mainly used fully for planning and management purposes. Finally, 'activity and challenge' and 'service and gathering' resemble traditional recreational mapping with an emphasis on functional services like recreational facilities promoting access, activities, and services. Mapping of these two classes was conducted using data from the Danish Forest and Nature Agency's outdoor recreation map combined with municipal and regional county data. Class 7 focuses on service-oriented facilities such as bus stops, parking lots, and toilets, while class 6 includes mobility-oriented facilities such as paths, trails, tracks, and waterways.

Several of the settings used for the seven experience classes include limits and area sizes that should be considered as normative. They are developed in dialogue with planners at GCA, thus reflecting existing planning approaches and experiences. The distinct definitions of criteria for each class establish a transparent set-up for the designation process.

Noise and disturbance

In line with the ROS concept, mapping of the first three recreation experience classes has involved limitation of the mapped experience settings by the use of disturbance mapping (see Table 2). A serene and peaceful nature experience is determined by the absence of urban-related disturbances such as minimum distance to urban settings (dense housing) and maximum noise levels due to proximity to major traffic corridors (auto, bus, train, and air). Distance criteria are derived through buffer analyses based on attributes of each traffic corridor with information of distances to minimum 55 dB (A) and minimum 45 dB (A). The 'wilderness' class includes a low-noise criteria at a level at 45 dB (A) because the perception of wilderness is promoted by an absence of man-made noise. In the nation-wide surveys from 1976 and 1993 on the recreational use of Danish forests that included 3000 persons, Jensen (1999) found that silence was the most appreciated quality. Hence class 1 also includes a noise distance criterion as a 250 m buffer to urban areas. The demands on the 'feeling of forest' experience include a noise level at 55 dB (A) due to the general assumption that this class is not as sensitive towards noise as the wilderness experience. The noise level was calculated by the Danish Road Directorate, and serves as guidelines for traffic noise from the state and (former) county roads, which includes all the major traffic corridors in Denmark. The noise calculation was based on number

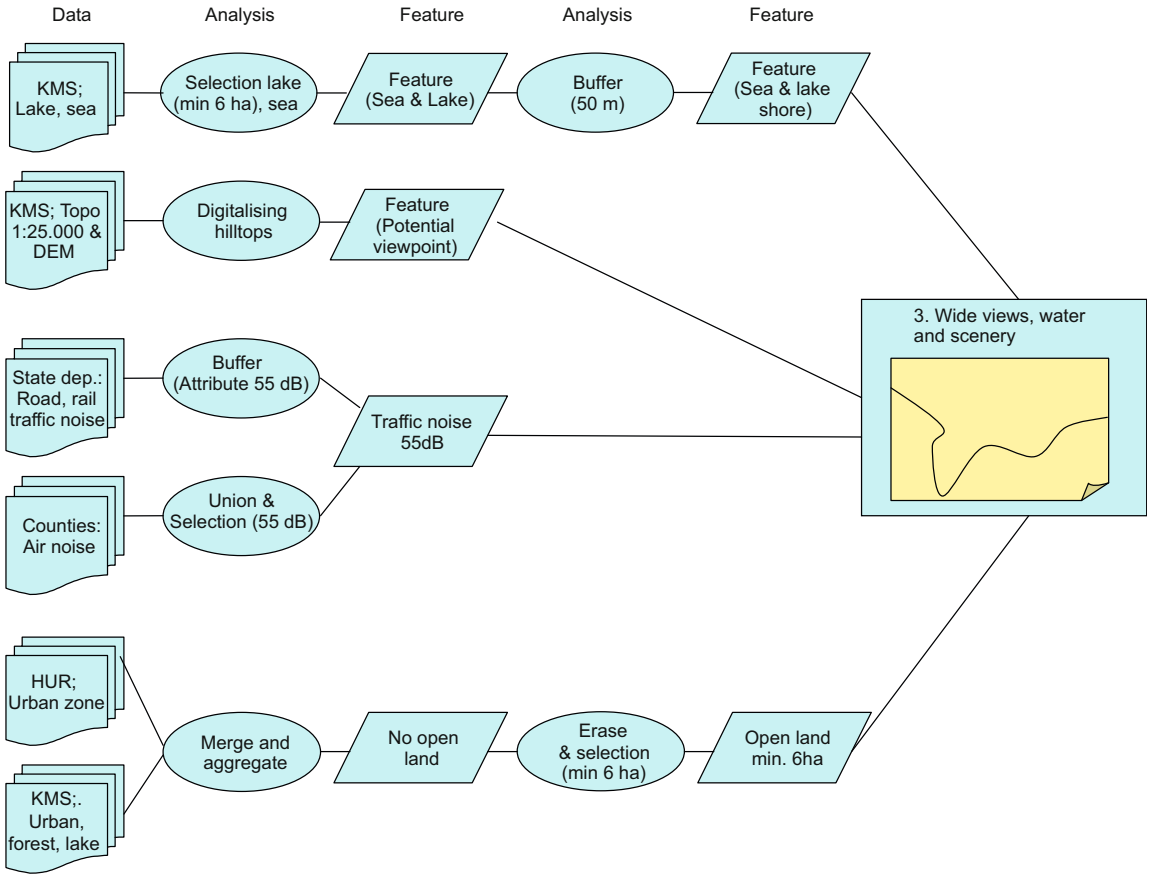

Fig. 3. Flowchart summarizing the main analytical steps in mapping of the recreation experience class 'Panoramic views, water, and scenery'. Using simple vector GIS analysis based on existing databases in the form of data selection and data extraction, digitizing, buffering, union, and aggregate, a new form of thematic map is generated. The map consists of landscapes and landscape elements such as sea and lake shores, viewpoints, and open non-built farmed landscapes that support experiences characterized by panoramic views and scenery. Areas affected by traffic noise are incorporated in the mapping to identify potential conflict areas where the experience opportunities could be disturbed. Buffers are made to selected features, and indicators are combined in the resulting experience map.

of vehicles, speed limits, and the amount of heavy vehicles, and do not include the effect of terrain, protective planting, buildings, and microclimate. Train noise is based on initial values from the Danish Environmental Protection Agency (Miljøstyrelsen, 1997), while airport noise was mapped by the former counties as part of the regional plan. Together, the noise datasets form a regional dataset suited for delimitation of nature-based recreation experiences in the region's green structure.

Designation analysis

The GIS mapping of each recreation experience involved multiple steps. An example of the processes and GIS analyses conducted in the mapping of 'panoramic views, water, and scenery' is presented in Fig. 3. Only the main processes and analyses are summarized in the figure, however it is conducted as a GIS analysis in which different themes are combined and selections are being made, some are transformed following the defined criteria, and finally the results are combined in the particularly experience map. For a full description of data input and analytical flowcharts for the mapping of all seven recreation experience classes, see Caspersen and Olafsson (2006).

Results

As part of the project, detailed land use analyses of the enlargement areas were conducted with respect to existing facilities and land ownership. In addition, a mapping of the future recreational potential was produced and divided into the seven experience classes. The analyses clearly showed the differences in the recreational development. The analysis and mapping method served as a platform for the ongoing discussions regarding the future green structure enlargement. The resulting shape of thematic maps facilitated dialogues between county officers from the GCA and planners from the involved municipalities and turned out to be beneficial to the future planning process. The project produced documentation of the potential experience values within the areas proposed for a future enlargement. With the abolition of the regional body in 2007, this documentation became increasingly important to the municipalities, which took over from GCA. The documentation describes the future enlargement for each area in question and also includes a detailed plan for the establishment of a new fourth green ring.

Using recreational indicators

To distinguish differences in recreational potential, maps were produced for the existing and future green areas; the indicators for the seven different recreational classes were developed, and the experience classes designated. It was decided not to aggregate or combine the different experience values into an index due to their very different natures, as a process of addition or indexing would be meaningless. Instead, the seven classes were kept separated and illustrated on separate maps. An example of the

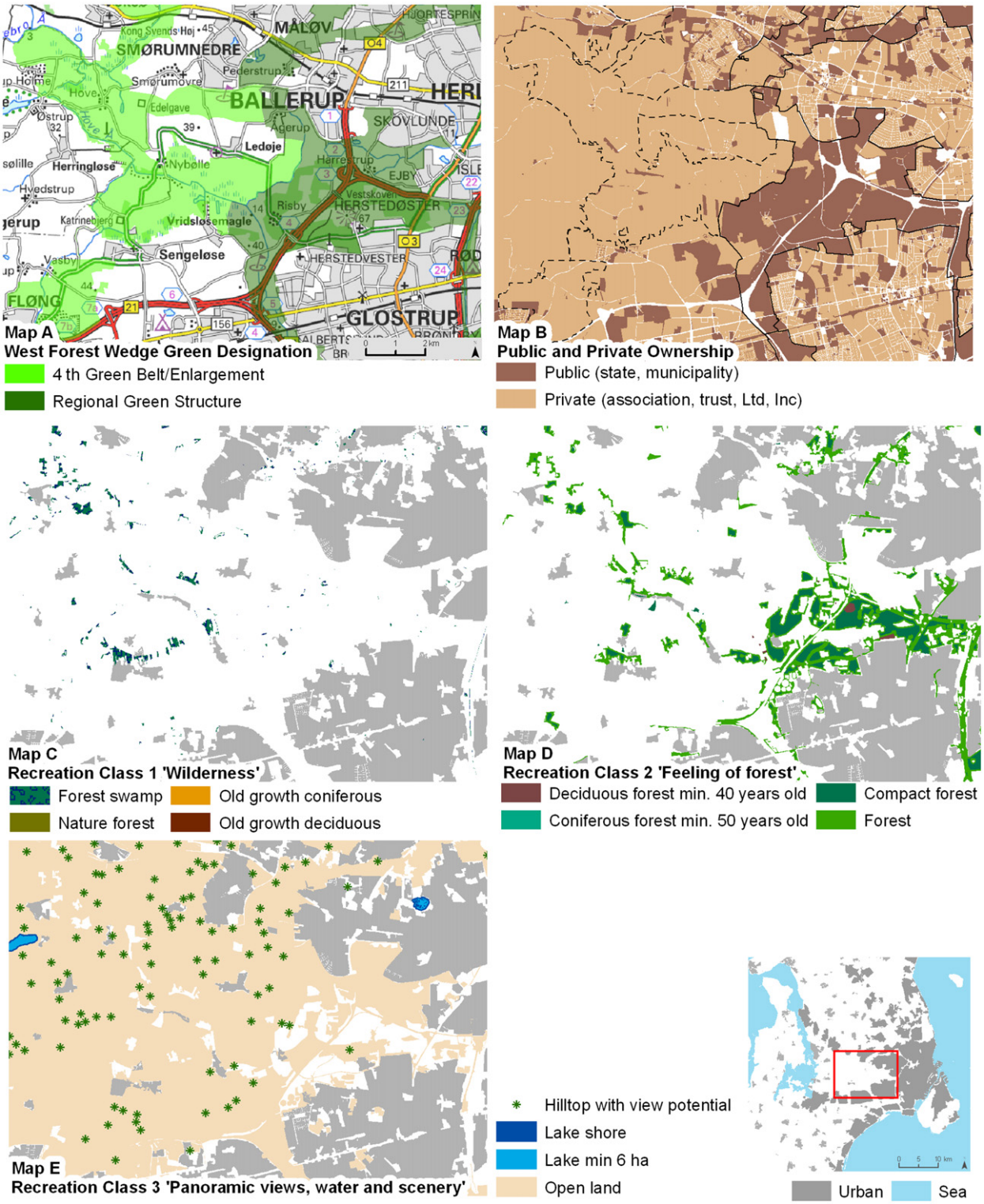

Fig. 4. This figure illustrates an example of the recreational analysis that was conducted within the greater Copenhagen city region. The selected area shows the existing south western part of the regional green structure in the form of the 'West Forest' wedge and the forthcoming green belt enlargement (map A). The other maps show spatial distribution of ownership (map B), mapping of experience class 1 (map C), class 2 (map D), and class 3 (map E) of the seven experience classes. See Table 1 for elaboration of the experience classes and Table 2 for background information on the mapping indicators.

mapped experience classes are illustrated in Figs. 4 and 5. The two examples illustrate the existing green structure and the future enlargement area at the 'Vestskoven wegde' situated in the urban fringe of western Copenhagen. The content of the seven experience maps in the present mapping process illustrated in Table 2 has been simplified due to the physical restrictions that relate to the reproduction of detailed maps at this scale, i.e. the 20 features of class 7 have been generalised to four different major features. Still what is typical for the mapping in general, and for this particular example, is the very large difference between the

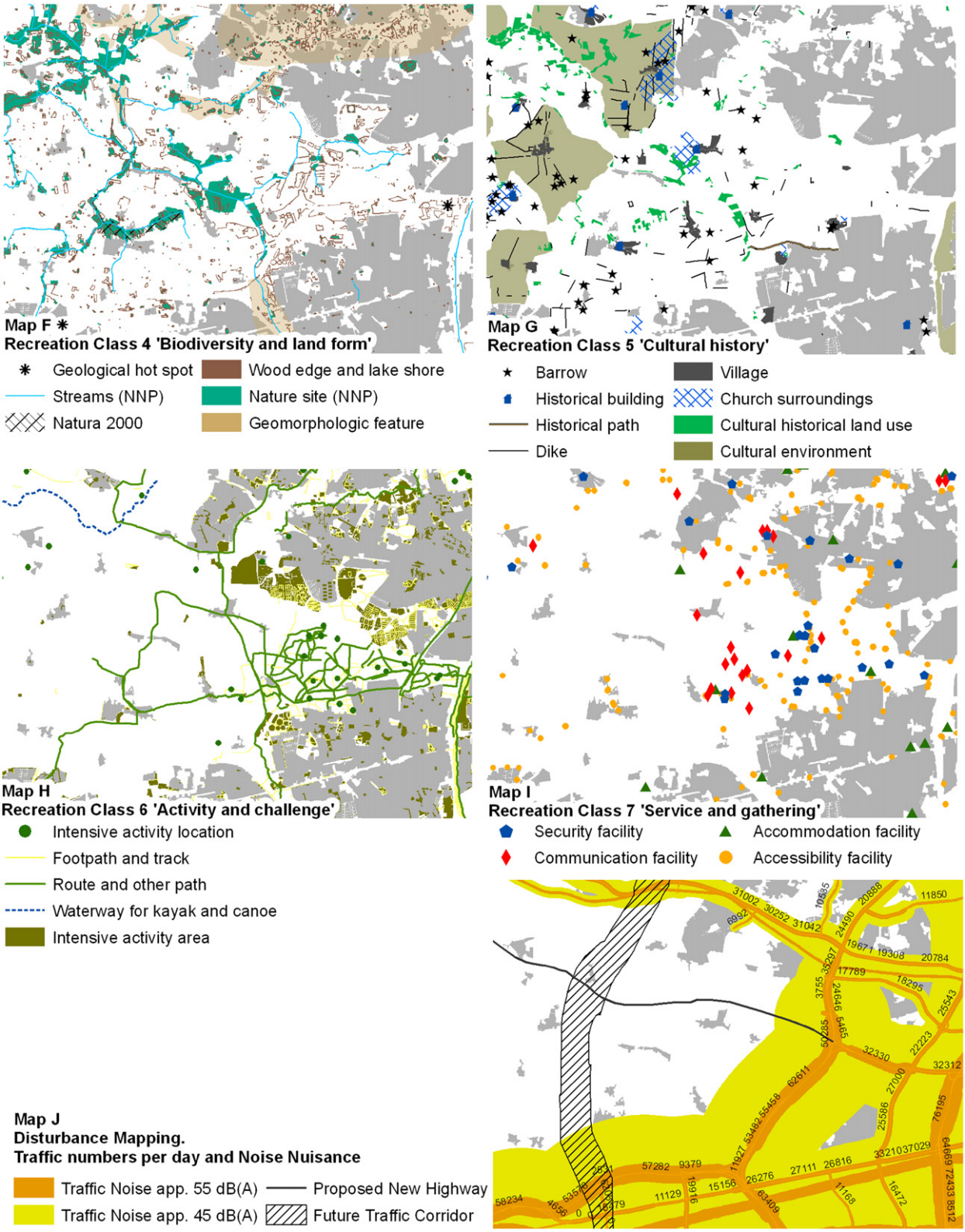

Fig. 5. Existing south western part of the regional green structure in the greater Copenhagen area in the form of the 'West Forest' wedge and the forthcoming green belt enlargement, and the mapping of recreation class 4 (map F), class 5 (map G), class 6 (map H), and class 7 (map I) illustrates the modelling of the disturbance derived from traffic noise at 45 dB(A) and 55 dB(A) noise levels. See Table 1 for elaboration of the experience classes, and Table 2 for background information on the mapping indicators.

experience classes in the developed and not-developed areas. The most developed areas in terms of recreational facilities are in the oldest inner areas close to the city. Here the green wedges now have character of urban parks with a large supply of recreational facilities accessible to visitors. The dominant experience classes in this area are the most developed classes 6 and 7. At a greater distance and near the urban fringe, the land use tends to be more agricultural and more 'natural', reflecting recreational

Table 3
Ownership for the present and future green structure: public (state, municipal, county); private (including association, trust); other (areas owned by different categories); unknown (areas not mapped).

Ownership	Fourth green ring (%)	Existing green structure (%)	Whole region (%)
Public	20.6	65.1	19.3
Private	74.7	25.4	76.1
Other	0.2	0.8	0.6
Unknown	4.5	8.7	4.0
Total	100.0	100.0	100

opportunities within classes 1–4. In other words, these maps provide the planners with information regarding structure and the facilities within the area that are useful for future recreational development. Due to the GIS-based mapping procedure, this information concerns not only this particular area but comprises the whole region.

Land ownership

The objective for Forest and Landscape was to provide site-specific information that could qualify the decisions regarding the future enlargement and thus improve planning and management procedures. An analysis of landownership was conducted as part of this process. The issue of ownership is important both for understanding the past and for the future development. Based on a national register of property-related data from the Danish Authority of Enterprise and Construction, an ownership map for the existing and forthcoming green areas was produced.

As illustrated in Table 3 and Fig. 4 (Map B), there are striking differences in ownership between the established and the future green structure. In the established green structure, approximately 65% is publicly owned and is being managed by the municipalities or the state. In the forthcoming green structure, only 21% is publicly owned. The large privately owned areas constitute a challenge for the future development and management of the green structure.

Planning use of the mapping result

The mapping result was used by GCA for developing detailed plans (named wedge plans) for subparts of the future green structure. The plans were developed in cooperation with municipalities for incorporation into the future spatial planning at municipality level. The GIS mapping of recreation experience opportunities provided the planners with information regarding the recreational potentials for the entire region. Hence, the data that was retrieved and combined in the GIS served as a general knowledge base and as a basis for detailed field studies in the subareas. This cross-municipal approach was new to the planners because the regional overview that included different experience classes had not been previously available. Hence, the maps assisted the development of detailed plans for future natural and cultural recreational values by illustrating existing experiences and facilities in the actual planning area and in the nearby areas. As an example, the information was used for the planning of facilities and a cross-municipal path system (HUR, 2006b). The mapping also gave a basis for an assessment of recreational experience effects such as noise disturbance and barrier effects of increased future traffic projects (HUR, 2006b), as outlined in Fig. 5, Map J. The new wedge plans that were developed by the municipalities and GCA in cooperation were officially launched at a 'summit', attended by the municipal mayors and by the minister of environment, in which the mayors signed a letter of intent regarding the future protection and development of the regional green structure.

Discussion

The development of greater Copenhagen has largely followed the original intentions of the Finger Plan, which for the last six decades has inspired urban planners and politicians. The plan has been decisive for the development of the general city plan, despite the fact that it was never actually implemented by law and has only recently been accorded formal planning status. The idea of a star-shaped city plan that enables easy access to green areas has been shown to be successful, even internationally, when compared with other European cities (HUR, 2006; Region Hovedstaden, 2008). In general, the development of the green areas has been conducted by different authorities from the state, region, and the involved municipalities; hence, different methods have been utilized for implementing recreational planning and development goals. The result is a green structure that comprises a very broad spectrum of different facilities. Due to the large number of different operators that have been active during the 60-year planning period, a regional overview, including an assessment of the recreational value, was never produced. Nonetheless, the expectations as to future expansion and competitiveness with other regions demand coordinated planning measures. The objective of developing a method that facilitates a detailed overview of the existing opportunities for recreational experiences in the present green structure is a departure from this demand. Additionally, it was the aim to analyze the recreational potential of future recreational areas. The expected population growth of additional 100,000 persons over the next 10 years makes a reform of the green structure necessary. Finally, the objective was to investigate the extent to which existing geo-information and GIS technology can provide the background for recreational planning and overview at regional and local scales.

The method developed was inspired by work conducted in Stockholm. The Swedish and Danish methods are both based on indicators in line with the conceptual approach in the ROS planning system. The GIS indicators summarized in Table 2 are predominantly normative expert assessments for selection of settings in the shape of indicators and criteria. It is clear that the coupling between settings and actual experiences in practice is individualistic depending on the situation, motivation, personal preference, etc. But the indicators are rooted in and correlated with Danish recreational research. Hence, the method differs in several ways from the Swedish approach. The applied limits and criteria are also defined through a dialogue between the involved scientists and planners. They should be primarily understood as an underscoring of the selected landscape features and scenic surroundings that could potentially support the experience classes outlined in Table 1. The use of existing planning designations together with the simplistic and hypothesized relationship among settings and expected experiences assists implementation and use of the planning method in spatial planning.

Creating a regional overview

With respect to the first objective, the method has shown itself to be feasible in creating the regional overview, classifying the existing opportunities for recreational experiences into seven distinct classes. This allows for a detailed assessment of the recreational values that are present in the region. The mapping indicates where developed and undeveloped areas exist with

respect to recreational opportunities. Additionally, it provides data about the abundance and type of elements within each of the experience classes. It thus ensures that the planning and management of the green structure will adopt a more comprehensive approach due to the specific and detailed knowledge that becomes available.

The second research question was aimed at developing an overview of the recreational potential, which relates to future enlargement areas in order to provide improved conditions for the development of future plans for the area. The developed method was useful in providing this information. The maps that were generated illustrate the landscape elements of importance for a future recreational development. Thus, it enables future development that utilizes the given physical conditions in the enlargement areas. In other words, the analyses show how the new enlargement areas can have a relatively large potential for recreational development within the first four experience values, these being less common in the existing regional green structure.

GIS as a methodological precondition

An important issue in the study was whether existing geoinformation and GIS technology provide the necessary background for recreational planning and overview at regional and local scales. The hypothesis was that the use of GIS facilitates that larger areas such as regions can be addressed, and at the same time, due to the recent development of high-resolution data, detailed information can be maintained that enable analysis and designations at local scales, such as the municipal level. However, the practical use of the mapping result has limits. It is intended for use at scale 1:200,000–1:20,000; for use at park level the map base requires additional data at 1:10,000.

Using thematic data combined into different thematic maps, high-resolution maps indicating possible experience classes can be illustrated at regional level. This also allows for analyses that address a particular area and which can correlate this to information that applies to nearby areas. The thematic mapping increases the available information and qualifies the planning process. The selected procedure combined with the present GIS technology supports the development of new rational planning methods that comply with demands for future planning methods, as stated in the Introduction. However, the developed system enables an overview at different scales and thereby provides information to be used in the planning and actual development of new recreational experiences and facilities.

The future of the regional green structure

Despite the growing amount of international research emphasizing the importance of green areas in proximity to residential areas, the goal of ensuring green areas close to urban settings has proven to be difficult to achieve. This process is seen in greater Copenhagen, as illustrated by Caspersen et al. (2006). The development of green wedges, analyzed for the period 1954–1998, showed a significant reduction of the green areas. The reduction was pronounced in periods where regional planning was accorded lower priority. As a consequence, the GCA focused its efforts on securing the necessary open space for future recreational development and preventing the development of new industrial and housing areas within the five green wedges. During this period, most areas have been protected by conservation or by public ownership (Vejre et al., 2007), while other areas have been protected only by designation and the intentions of the 1947 Finger Plan (Caspersen et al., 2006). New green areas have been developed mainly by changing the agricultural land use to more specific recreational use, in line with the existing planning policy. The forest 'Vestskoven' is an example (indicated in map D of Fig. 4). The 1400 ha forest was established in 1967 as an urban forest on land owned or purchased by the State and the involved municipalities. Hence, the recreational development in the forthcoming enlargement areas represents a special challenge due to the private ownership, which dominates in these areas (Fig. 4 map B). With many interests connected to these areas and the demand for new construction sites and forthcoming demands for a future enlargement of the infrastructure, setting aside land for use as recreational area could turn out to be very difficult or expensive. Nonetheless future investments should be focused so that they benefit from the existing physical conditions in the undeveloped areas. The mapping method helps to reveal the recreational experience potentials in those areas. The method is therefore effective in reducing the costs of the future development of the new enlarged recreational areas.

Conclusions

This study builds on a long tradition for recreational planning rooted in the ROS planning system. Dramatic improvements in the techniques and opportunities for mapping over the last decade have made detailed recreational experience mapping less costly and time consuming. This has meant that the division of recreational experiences into different classes as conducted in the ROS planning system becomes more feasible. The Swedish experience with synthesizing the experience values into seven distinct classes was adapted and transformed according to Danish conditions. This includes adaption to the recreational landscape settings in greater Copenhagen and correlation with Danish recreation research findings. Indicators were divided into three different types: visual, audiovisual, and functional services, which relate to the seven experience classes. The mapping was applied to the planning process in which detailed 'green wedge plans' were produced for various parts of the undeveloped areas in the green structure. The method has shown the same advantages as in Stockholm for mapping the recreational potential of the existing green structure. In addition, the example from greater Copenhagen illustrates that the method is useful for analysis and assessment of an area being developed for a recreational purpose. However, such an assessment requires access to high-quality GIS data. In assessing the greater Copenhagen area, we relied on GIS and map-based indicators in order to create a transparent background for the mapping process. The formulation of the exact mapping criteria reflects the planning need and has been carried out in collaboration with the green structure planners at GCA. The use of GIS and map-based indicators for each of the seven defined experience classes enables a relatively rational and time-effective mapping process. This will in turn make possible subsequent monitoring of the recreational development. Based on this study, we believe that the mapping method constitutes an efficient planning tool within the recreational sector for larger city regions.

Acknowledgements

The authors would like to thank Bette Malmros of the Stockholm Regionplane och Trafikkontoret for her advice during the early phase of the development of the Danish method for mapping of recreational experiences. They also wish to thank the planners Jan Engell and John Fernley Paine from GCA for cooperation during the Interreg III A project 'The Landscape as Resource'.

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