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Managing the potential for outdoor recreation: Adequate mapping and measuring of accessibility to urban recreational landscapes

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ABSTRACT

Following the increasing public health concerns related to physical inactivity in the population, the relationship between outdoor recreation and public health has been increasingly acknowledged over the last decades. To improve public health, planners and policy-makers aim to provide good accessibility to recreational landscapes to facilitate outdoor recreational activity. At the same time, they are facing development pressure due to urban growth. In order for planners and policy-makers to secure people access to urban and near urban recreational areas, there is a need to map and measure access in a way that is adequate as a basis for decision-making in planning and design processes. Access is often defined as distance, or proximity, from residents' homes to recreational areas. This paper explores different ways to map and measure distance to recreational areas, and aims to provide better decision support for planners and decision-makers. Moss municipality in Norway serves as a case study. We begin by addressing the meaning of the term 'recreational landscape' and how the choice of definition affects the results when mapping recreational areas. We also discuss who we are measuring distance for, and how different user groups will have different thresholds or critical distances affecting their frequency of visits to a recreational area. Last, we explore different methods for measuring distance within a GIS environment. The paper shows how the purpose of the analysis must be decisive when defining recreational landscapes and choosing methods for measuring access to recreational landscape, in order to provide valuable input to planners and policy-makers aiming at enhancing the possibility for outdoor recreation for people.

Introduction

Over the last decades there has been increasing political concern over rapidly emerging public health issues related to physical inactivity in the population. Physical inactivity is a major risk factor related to many current health challenges, including obesity and non-communicable diseases such as cardiovascular diseases, cancer and diabetes (World Health Organization, 2010). In recent years, the relationship between outdoor recreation and public health has been increasingly acknowledged, and provision of recreational landscapes is seen as a means to increase physical activity and improve public health (Pate et al., 1995; Dahmann et al., 2010; Mann et al., 2010; World Health Organization, 2010). The positive health effects of outdoor recreation are both related to visual exposure to natural environments (Velarde et al., 2007) and to the physical activity itself (Grahn, 1994; Schantz, 2003). There may also arise synergic benefits from being physical active whilst simultaneously being exposed to nature (Hartig et al., 1991; Arksey and O'Malley, 2005; Pretty et al., 2005). Recent research has further shown that the distance or proximity to a recreational landscape affects how people perceive their own health (Van den Berg et al., 2010). In addition to serving as arenas for outdoor recreation, urban and near urban recreational landscapes also provide ecosystem services such as reduced noise levels and improved air quality, affecting public health (De Ridder et al., 2004).

Time, motivation and mobility are important prerequisites for people to engage in outdoor recreation. In addition, people must have access to recreational landscapes. Urban and near urban recreational landscapes (for instance forests, coastal areas and parks) are important as landscapes for everyday outdoor recreation, and loss and fragmentation of green space near residential areas may reduce people's access to recreational landscapes. As many cities in Europe face extensive growth and increasing parts of the populations live in urban areas, securing access to recreational areas close to one's home is rapidly becoming a challenge to urban planning. Current compact city strategies put additional pressure on green structure within the city. Although densification as a planning ideal for urban municipalities may provide several benefits for the environment; for instance reduced private car use,

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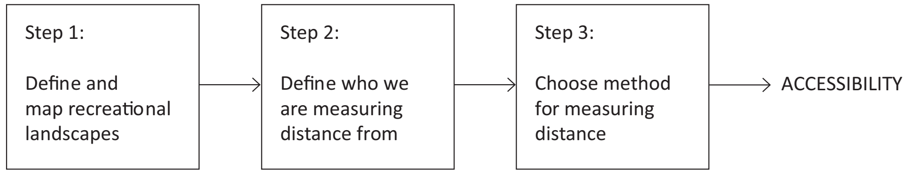

Fig. 1. Steps in mapping and measuring accessibility to recreational landscapes.

preservation of cultivated land and safeguarding nature and biodiversity in undeveloped rural areas, densification also has the disadvantage of adding pressure to urban and near urban green space (Thorén, 2000; Stokke and Falleth, 2010; Jørgensen and Thorén, 2012).

Access to recreational areas need to be measured and analyzed as part of planning processes in order for planners and policymakers to be able to compare the effects different scenarios, and understanding how people perceive their access to recreational areas is an important basis for urban green structure management. However, a review of how the terms access and accessibility are defined and applied in present research on outdoor recreation reveals that the terms hold several different dimensions. A main distinction can be identified between physical accessibility and cultural, social and socio-psychological accessibility. Cultural, social and socio-psychological accessibility is related to attributes of the user, for instance cultural and social background, gender, age, mobility and recreational preference. These attributes affect the tradition people have for outdoor recreation, their experience, knowledge and sense of safety in a recreational landscape, all of which may affect people's perceived accessibility to a recreational landscape. Physical accessibility, or accessibility related to attributes in the physical landscape, involves both internal access (access *within* a recreational area) and external access (access *to* an area from the outside). The internal accessibility of a recreational landscape depends on attributes such as topography, vegetation structure and infrastructure (footpaths, trails and forest roads) and affects to what degree we are able to move around within an area.

While the internal access is important when at a site, or as a quality factor when determining where to go, the external accessibility has a major impact on how often we choose to visit a recreational area (Gobster, 1995; Van Herzele and Wiedemann, 2003; Skov-Petersen and Goossen, 2009). The main focus in this paper is therefore the external access to recreational landscapes. External physical access is often defined as distance, or proximity, from resident's homes to recreational areas, and measured in number of metres (Hörnsten and Fredman, 2000; Ode and Fry, 2006; Neuvonen et al., 2007).

Recreational areas can be reached by foot, bicycle, car or public transportation. However, policy documents and recommendations regarding distance or proximity to recreational landscapes tend to focus on pedestrians and walking distance (Nordic Council of Ministers, 1996; Norwegian Institute of Public Health, 2009). Being able to reach a recreational area by foot also means that people will have a lower threshold for using the area for outdoor recreation. How people perceive actual walking distances will however differ depending on for instance age or level of mobility. People of different age group and level of mobility will have different limits for how far they are willing to walk to get to a recreational area. According to the Norwegian Institute of Public Health, the limit for how far people will walk or cycle to reach a recreational area is around 10 min. In practice this means maximum 400 m for children and elderly. The number of visits to a recreational area is reduced by 56% when it is further away than 500 m from people's homes (Norwegian Institute of Public Health, 2009).

The Nordic Council of Ministers (1996) recommends 250–300 m as a maximum walking distance to recreational areas for everyday use. This recommendation is referred to by Hörnsten and Fredman (2000), Ode and Fry (2006) and Neuvonen et al. (2007). According to Hörnsten and Fredman (2000) longer walking distances can function as a barrier for recreation.

Neuvonen et al. (2007, p. 237) explain how this distance barrier is related to time; "*In terms of available time during weekdays, most working people have somewhat restricted possibilities to engage in recreation outside their own residential area.*" In order for people to use a recreational area, it has to be situated within a certain proximity to their homes. Research confirms a correspondence between a recreational area's distance to built-up areas and the frequency of recreational use of these areas (Gobster, 1995; Van Herzele and Wiedemann, 2003). Van Herzele and Wiedemann (2003, p. 111) show that "*people who live in close proximity to a green space use it frequently, those who live further away do so less frequently in direct proportion to the increase in distance.*"

Assessing people's access to recreational landscapes may seem like a straight-forward process. However, in order to map and measure distance to a recreational landscape; three main questions need to be answered. First, what are we measuring distance to? How do we define and map a recreational landscape? Second, who are we measuring distance for? And third, how should distance be measured? These questions represent three separate steps in an analysis, where the choices made will affect the outcome of the analysis (see Fig. 1).

This paper explores how choices made within the different steps affects the outcome of the analysis and hence the basis for decision-making. The aim is to provide valuable input to planners and policy-makers aiming at enhancing possibilities for outdoor recreation for citizens and comparing different scenarios of densification. When mapping and measuring access to recreational landscapes, definitions and methods applied must be transparent in order for planners and policy-makers to assess whether the measurements are adequate for the purpose of the analysis. Different data sources are applied and explored to exemplify different methods for measuring access. Both data sources and methods will be discussed and evaluated with regard to their ability for assessing access.

Methods

Steps in mapping and measuring distance to recreational landscapes

The first step of the analysis is to define and map recreational landscapes. One need to consider what characterizes areas that are suitable for recreation and opposite; consider what characterizes areas that are unsuitable for recreation. Depending on the definition applied, different land cover categories should be included. In the first part of the result section we illustrate how different definitions of recreational landscape affect the mapping of these areas.

The second step is deciding for whom we measure distance to recreational landscapes, and choosing adequate data sources to address this. Distance measurements can be based on either housing data alone or housing data combined with population survey data. The discussion regarding the type of information that could be obtained with the different sets of data for a study area and the

Table 1
Data sources used for mapping recreational landscapes and measuring distance.

Data source	Content used in GIS analysis	Date of download	Level of detail
Common Map Base – CMB (Felles Kartbase – FKB)	CMB land resource CMB building CMB road situation	16.02.2012	Geographical scale: 1:5000
Topographical map – N50	N50 land cover	16.02.2012	Geographical scale: 1: 50000
Orthophoto	Orthophoto	12.03.2010	Resolution: 0.1 meters

advantages and disadvantages of applying different data sources will be presented in the second part of the result section.

The third step involves decisions regarding types of distance measurements within a GIS environment; buffer analysis and network analysis. Buffer analysis measures distance in linear distance, while network analysis measures distance through existing infrastructure. Within the third part of the result section we will illustrate how the different methods of measuring distance affects measurements of availability and accessibility of recreational landscapes.

Both the choices made within each step and the distance measurements that follow from these choices, are part of the results. Because of this, the methodological choices made are explored further in section "results".

Study area: Moss municipality and Mosseskogen

Moss municipality serve as a study area for mapping and measuring distance to recreational landscapes. Moss was chosen as a study area because it represents a middle-sized urban municipality in Norway, and is experiencing development pressure on its recreational areas due to urban growth. In addition, Moss has areas of recreational value both in forests and along the coast, and the recreational areas in the municipality therefore consist of various land cover categories. Moss is situated in Østfold County on the east side of the Oslo fjord. It has an area of approximately 58 km^2, and a population of just over 30 000 inhabitants (Statistics Norway, 2011). Areas 1 km into the adjacent municipalities (Vestby, Våler and Rygge) are included in the analysis, since the population in Moss that lives near the municipality border might have their nearest recreational area outside the municipality.

For illustrating methods to measure external access to recreational landscapes we are using the whole of Moss municipality (and areas 1 km into the adjacent municipalities) as well as a selected part of Moss which includes a recreational forest called Mosseskogen. Mosseskogen was chosen because of its use as a daily recreational area typical to the Norwegian context. A buffer analysis is conducted for the entire municipality, and for Mosseskogen both a buffer and a network analysis are conducted. In the network analysis, distances to the nearest entrance to the forest are measured. This type of analysis demands a registration of existing entrances, and hence field inventories. Because of the demand of more detailed data, network analysis is too labour intensive to perform for the whole municipality, and is therefore only carried out for Mosseskogen.

Data sources used in the GIS analysis are listed in Table 1. The data are retrieved from 'Norway Digital' ('Norge digitalt', www.norgedigitalt.no), managed by the Norwegian Mapping Authority and from 'Norway in pictures' ('Norge i bilder', www.norgeibilder.no), managed by the Norwegian Mapping Authority, Forest and Landscape and the Norwegian Public Roads Administration. All map layers are national, and can be accessed for all Norwegian municipalities.

Both Common Map Base (hereafter abbreviated as CMB) and N50 topographical map contain data layers holding information of land cover. Together with orthophotos, these layers are applied when mapping recreational landscapes in Moss municipality. CMB also contains map layers of infrastructure and buildings.

Results

Choices in defining and mapping recreational landscapes

In order to measure distances to recreational landscapes, one must firstly define and secondly map these landscapes. If a recreational landscape is understood as a landscape that facilitates outdoor recreation, several different definitions are possible. Some research on recreational landscapes focus on forest cover or woodland (Hörnsten and Fredman, 2000; Arnberger, 2006; Ode and Fry, 2006; De Clercq et al., 2007; Gundersen and Frivold, 2008; Colson et al., 2010), a land cover category that clearly falls within the core of a definition of a recreational landscape. Other research use corresponding terms such as 'green areas', 'green structure' or 'green space' (Van Herzele and Wiedemann, 2003; Jim and Chen, 2006; Neuvonen et al., 2007; Comber et al., 2008; Caspersen and Olafsson, 2010; Schipperijn et al., 2010), and thus include a wider range of land cover categories, for instance coastal areas, agricultural areas and other types of open land without forest vegetation. It can also be discussed whether the vegetation in an area have to be 'natural', or if parks can be considered as recreational landscapes (Emmelin et al., 2010).

To illustrate how different definitions of recreational landscapes affect the spatial distribution of these, we mapped recreational landscapes in Moss municipality based on three different definitions:

A. Recreational land constitutes of forest.
B. Recreational land constitutes of land with public right of access, which includes forest, coastal areas, parks and other open land.
C. Recreational land constitutes of land with public right of access in wintertime, which in addition to forest, coastal areas, parks and other open land in Norway also include agricultural land since the public right of access is applied to these areas during the winter months.

The mapping does not take into account the visual qualities of the areas, or the areas suitability for recreational activities. It is therefore more correct to say that areas with *potential* for recreational use are mapped, than to say that recreational areas are mapped. Municipalities often have their own maps of registered recreational areas. These maps may however omit the informal areas used for recreational activity.

Two final maps were produced showing the spatial distribution of areas for recreation in Moss municipality (Figs. 4 and 5). The first map shows the areas with potential for recreational use according to definition A and B; areas with forest cover and additional areas with potential for recreational use in the summer months. The second map shows areas with potential for recreational use according to definition B and C; areas with potential for recreational use in

Table 2
Overview of definitions of areas with potential for recreational use, related map layers and land cover categories included.

Definition	Map layer	Land cover categories included
A: Recreational land constitutes of forest	Map of forest cover	CMB forest CMB peat bog
B: Recreational land constitutes of land with public right of access, which includes forest, coastal areas, parks and other open land	Map of areas with potential for recreational use in the summer months	CMB forest CMB peat bog CMB open land and N50 river/stream, lake, sea, park or forest CMB open land and N50 open area sorted using orthophoto
C: Recreational land constitutes of land with public right of access in wintertime, which includes forest, coastal areas, parks, agricultural land and other open land	Map of areas with potential for recreational use in the winter months	CMB forest CMB peat bog CMB agricultural land CMB open land and N50 river/stream, lake, sea, park, forest or agricultural land CMB open land and N50 open area sorted using orthophoto

the summer months and the additional areas with potential for recreational use in the winter months.

Table 2 gives an overview of the different map layers and land cover categories included in the maps according to the different definitions of recreational landscapes. The mapping procedures are illustrated in the dataflow diagram in Fig. 2, and described in the following.

The maps are processed from data sources originally acquired for other purposes than to document areas with recreational value. Some of the land cover categories in these data sources correspond well with our definitions of recreational landscapes, and are included in the final maps without further processing. This applies to the forest cover of Moss; the map layer of areas with potential for recreational use according to definition A consist of the predefined land cover categories 'forest' and 'peat bog'. The areas with potential for recreational use according to definition B and C, include open land with public access, and these areas are more problematic to map. The land cover category 'open land' covers different types of land cover, and potentially includes areas suitable for recreational activity. Areas from this land cover category are included in the final maps after further sorting; first with the topographical map, and second with orthophotos. Areas classified as CMB 'open land' and N50 'river/stream', 'lake', 'sea', 'park', 'forest' or 'agricultural land' are included in the final maps according to definition B and C. Areas classified as CMB 'open land' and N50 'developed area', 'sports ground', 'industry', 'stone quarry/gravel deposit' or 'cemetary' are excluded. Areas classified as CMB 'open land' and N50 'open area' are sorted further using orthophotos.

Fig. 3 illustrates 6 different areas sorted using orthophotos. Pictures A and B show areas that clearly have no potential for recreational use; a waste dump and a development area. Pictures C and D show areas that clearly fall within the definition of a recreational landscape; forest covered hills and a coastal path. These areas are unproblematic to sort according to our definitions of recreational landscapes. Pictures E and F illustrate areas that are more difficult to sort, as they contain more than one land cover category. For these areas we considered whether it was more appropriate to include areas that did not have potential for outdoor recreation, than to exclude areas that had. Picture E shows an area that includes both valuable beach areas, areas that function as winter storage for boats and a private summer house. Areas close to the summer house are not accessible for the general public, and areas to store boats during the winter might not be suitable for recreation. The area as a whole is still included in the final maps to prevent losing the beach areas that is highly valuable for recreation. Picture F shows an area that mainly contains residential properties with private gardens, but with a small stripe of sandy beach with public right of access along the coast. This area was not included in the final maps since the rest of the stripe of sandy beach outside this area was included.

This type of manual sorting was done to areas larger than 5000 m^2 and also smaller areas in densely populated areas.

In addition to the sorting of the areas in Moss municipality with regard to land cover category, two additional criteria for what is to be considered as areas with potential for recreational use are added. The first criterion is related to distance to the motorway that runs through Moss municipality. Areas close to the motorway are not suitable for outdoor recreation because of noise and the visual impact of the road. In the final maps, we chose to not include areas that are within 25 m to the motorway, as well as the main roads connected to the motorway. The actual distance for which the motorway will influence the potential for recreation due to noise and visual impact will depend on physical landscape factors such as terrain form and vegetation, but also individuals' tolerance to such disturbance for recreational activities will vary. The second criterion is related to the size of the area. After merging all areas together in the three maps, areas less than 5000 m^2 are eliminated, as the Norwegian Ministry of the Environment consider 5000 m^2 as the minimum size of a "play- and recreational area" (Norwegian Ministry of the Environment, 1993).

The final maps are displayed in Figs. 4 and 5. The area categories in these maps represent the three definitions of recreational landscapes formulated. Table 3 gives an overview of the size of areas with potential for recreational use according to the different definitions of recreational areas, and the percentage of the total area.

Overall, the maps show that Moss municipality, extended 1 km outside the municipality border, have large areas with potential for recreational use. The forest areas cover 53.9 km^2 or 63.3% of the total area. When including the additional areas sorted from CMB 'open land' the areas with potential for recreational use increase slightly; these areas cover another 3.2 km^2. However, the map in Fig. 4 shows that even though the additional areas included are small, some of these areas are placed within developed areas. The inclusion of these areas will therefore have a spatial impact and are likely to affect the results when measuring peoples distances to the nearest recreational area. The amount of forested area in Norwegian municipalities varies, and in municipalities with a small amount of forested area, including open land with public access will have greater impact on the areas mapped.

The map in Fig. 5 shows how the area with potential for recreational use increases when adding agricultural areas where the public has right of access during the winter months. In the winter season 68.8 km^2 or 80.8% of the mapped area may function as recreational areas. The additional area included in this map, is however located in the fringe areas of the municipality, so it might not have a great impact on the distance measuring.

From this mapping we can see how the application of specific definitions of what constitutes a recreational landscape affects

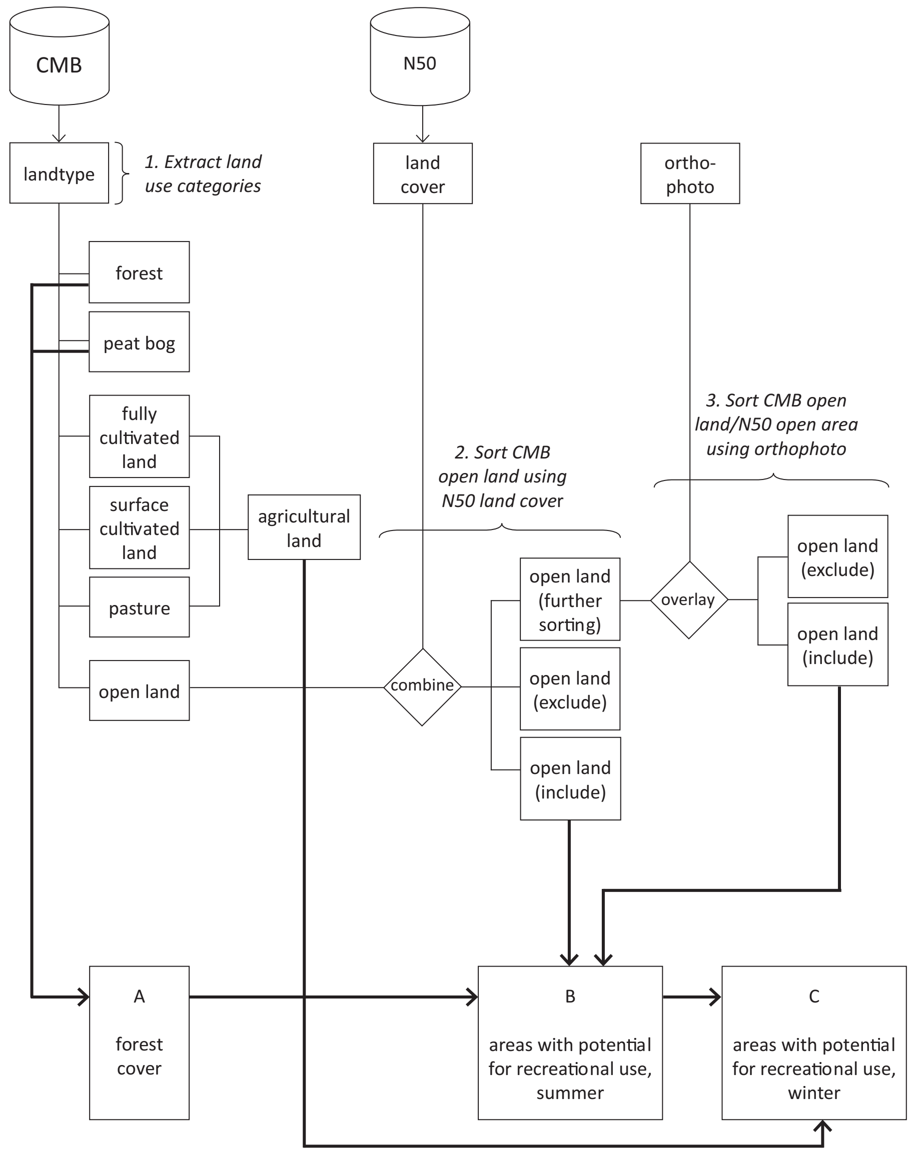

Fig. 2. Dataflow diagram summarizing the mapping of areas with potential for recreational use in Moss municipality.

both the number and size of areas identified and their spatial distribution.

Choices regarding who we measure access for

Measuring distance to recreational landscapes involves asking the question for whom we are measuring distance. As mentioned, people of different age group and level of mobility, will have different limits for how far they are willing to walk to get to a recreational area. Therefore it can be interesting to identify user groups with different mobility we want to measure accessibility for.

A limitation to the analysis that can be conducted in a GIS environment is that the information needs to have a spatial format. Since people move around and are not placed on fixed coordinates in a coordinate system, population survey data need to be combined with spatial data (for instance housing data) in order to measure distances to recreational areas. Using population survey data combined with spatial data, one can answer general questions such as 'How many people live within 250 m of a recreational area?' or more detailed questions, such as 'How many children (under 18 years) live within 250 m of a recreational area?' Both De Clercq et al. (2007) and Neuvonen et al. (2007) measures distance with population survey data in a spatial format. However, issues of privacy often limit access to and use of population survey data in combination with housing data.

Another option is to base the analysis on housing data. When using housing data in the analysis one can answer questions about how many buildings that are located within certain distances to a recreational landscape. Housing data does not hold information on how many people that live in each household, their age, gender or

Table 3
Overview of the size of areas with potential for recreational use according to the different definitions of recreational areas, and percentage of total area.

Area	Size (km^2)	Percentage of total area
A: Map of forest cover	53.9	63.3
B: Map of areas with potential for recreational use in the summer months	57.1	67.0
C: Map of areas with potential for recreational use in the winter months	68.8	80.8
Total land area of Moss municipality including the area 1 km outside the municipality boarder	85.2	100.0

Fig. 3. Areas classified as both CMB 'open land' and N50 'open area', sorted by orthophotos.

other relevant information about the residents. However, housing data available from 'Norway Digital' allows us to separate buildings into different housing categories; detached houses, semi-detached houses, terraced houses and larger buildings. In this way, housing data can give some indication of the socio-economic situation of the residents (Evans et al., 2000; Grundy and Sloggett, 2003; Costa-Font, 2008). Using housing data, it is possible to analyze if there are inequalities in accessibility between residents of different housing categories. This means that in a planning and design process it is possible for planners and policy makers to set as a goal that all residents should have recreational areas within a certain proximity independent of housing category.

Since population survey data rarely are freely available, and housing data more often are easy to access, we have chosen to apply housing data further in our analysis. This choice limits the possible analyses that can be conducted. It is important to note that when available, population survey data is highly preferable.

Choice of method for measuring distance

As mentioned, there is a correlation between the distances people have to walk to reach a recreational area and how frequently they use it (Gobster, 1995; Van Herzele and Wiedemann, 2003; Norwegian Institute of Public Health, 2009; Skov-Petersen and Goossen, 2009). Walking distance to recreational areas for everyday use is recommended to be maximum 250–300 m. 250–300 m is a critical distance for children and elderly to reach recreational areas by foot within an adequate amount of time (Nordic Council of Ministers, 1996; Hörnsten and Fredman, 2000; Ode and Fry, 2006; Neuvonen et al., 2007). On the basis of these recommendations, thresholds of 250 m, 300 m, 500 m and 1000 m were chosen as critical distances for recreational use in our analysis.

In the literature, there has been two predominant ways of measuring distance using GIS; buffer analysis and network analysis (Chrisman, 2002). Buffer analysis measures linear distances, as in our study the linear distance between residential buildings and recreational areas. Buffer zones of different distance intervals can be calculated around recreational areas, and from this the number of residential buildings within each distance interval can be calculated. However, people are rarely walking linear distances. To reach a recreational area, people have to follow paths and roads from their home leading to an entrance. The distance people have to walk to reach their nearest recreational area, is therefore affected by infrastructure (Dramstad et al., 2001; Geurs and van Wee, 2004; Jim and Chen, 2006; Comber et al., 2008; Colson et al., 2010). Network analysis measures actual distances between residential buildings and the nearest recreational area (or the nearest entrance to a recreational area) following road and path infrastructure.

Presence of entrances or access points that leads into the terrain are necessary for peoples external access to recreational landscapes (Van Herzele and Wiedemann, 2003; Arnberger, 2006; Comber et al., 2008; Caspersen and Olafsson, 2010; Colson et al., 2010). Entrances can be both formal and informal. Formal entrances can provide facilities like parking areas or bus stops (Caspersen and Olafsson, 2010), or notice boards with information about the history and nature in the area, alongside a map with suggested walking

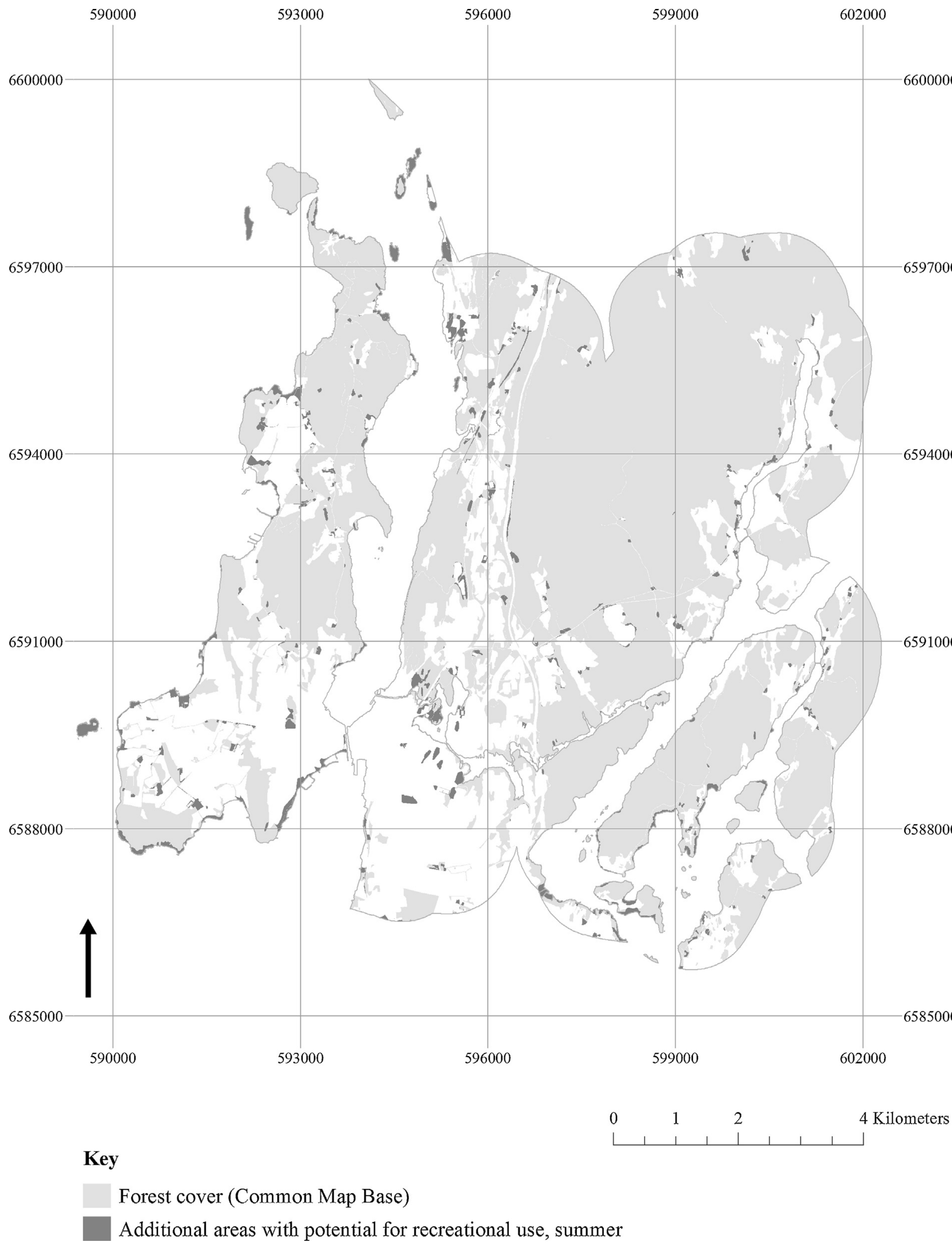

Fig. 4. Map of forest cover in Moss municipality and additional areas with potential for recreational use in the summer months.

trails or viewpoints. An informal entrance may be a small footpath leading directly into the terrain.

It is possible to perform a network analysis without recording the entrances to the recreational area first. Then the distance from residential buildings, via existing infrastructure and to the border of the recreational area is calculated. This method is applied for a Norwegian national statistic on 'areas for outdoor recreation and close-to-home recreation' conducted by Statistics Norway (Engelien, 2012). Measuring the distance to the nearest entrance to a recreational area is inevitably a more accurate measure of the actual distance people have to walk to reach a recreational area. Performing a network analysis measuring distances from

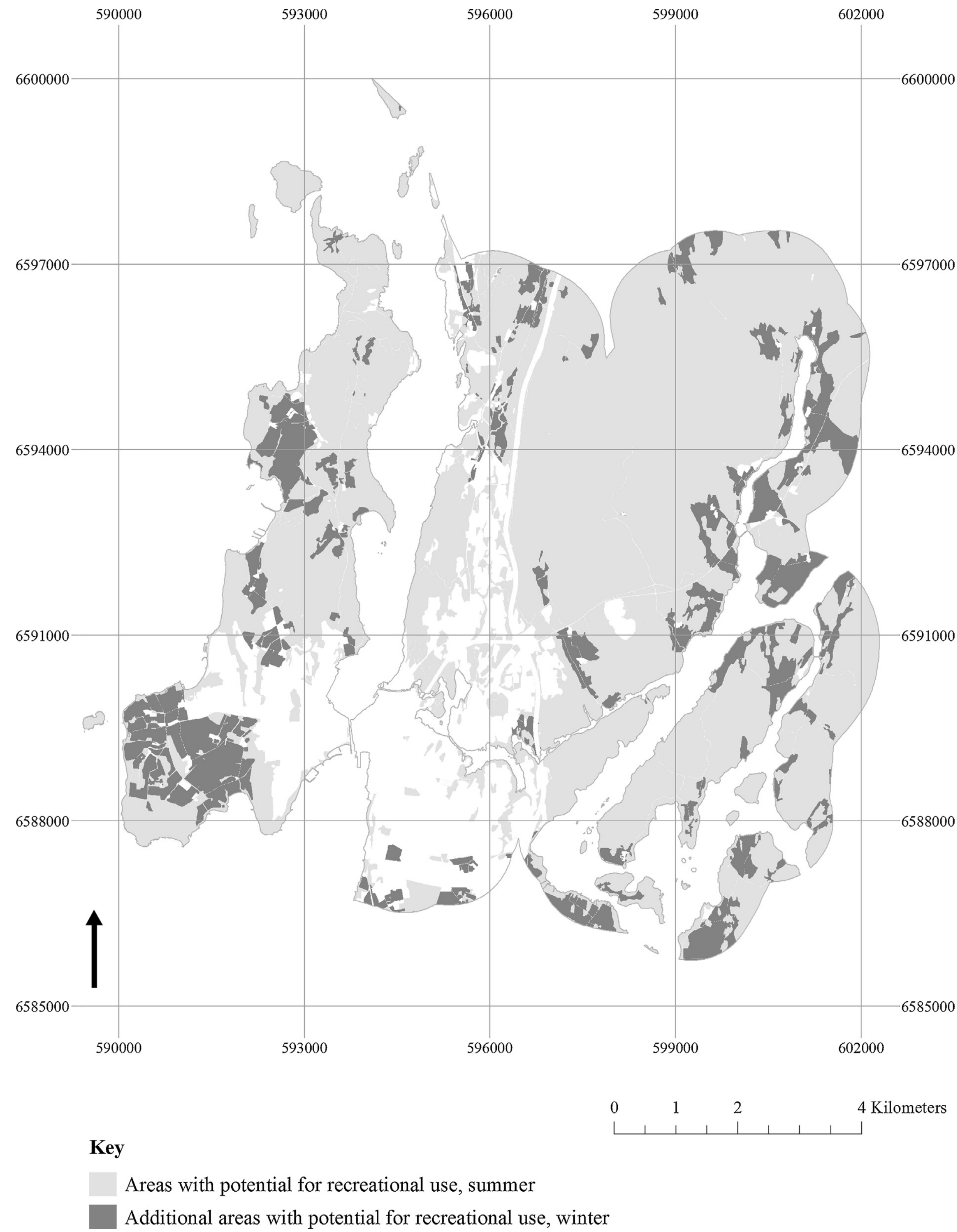

Fig. 5. Map of areas in Moss municipality with potential for recreational use in the summer months, and additional areas with potential for recreational use in the winter months.

residential buildings to the nearest entrance to a recreational area requires recording of the entrances to the recreational area that is studied. Unless very detailed maps are available (for instance orienteering maps) this recording demands fieldwork for accuracy. Because of this, network analysis is often much more labour intensive than buffer analysis. The relevance and feasibility of buffer analysis and network analysis are therefore often related to different geographical scales.

For the whole of Moss municipality, a buffer analysis is carried out to measure linear distance between residential buildings

Table 4
Distribution of residential buildings of different categories within different distances to areas with potential for recreational use (percentage and number of buildings).

Housing category	Definition of recreational landscape	Within 250 m	250-300 m	300-500 m	500-1000 m	Total
Detached houses	Forest cover	79.8 (3608)	3.8 (172)	8.2 (372)	8.1 (368)	100.0 (4522)
	Potential for recreational use, summer	92.9 (4200)	3.6 (163)	3.5 (159)	0.0 (0)	
	Potential for recreational use, winter	93.2 (4214)	3.4 (154)	3.4 (154)	0.0 (0)	
Semi-detached houses	Forest cover	61.3 (466)	5.8 (44)	18.2 (138)	14.7 (112)	100.0 (760)
	Potential for recreational use, summer	84.3 (641)	6.2 (47)	9.5 (72)	0.0 (0)	
	Potential for recreational use, winter	84.5 (642)	6.2 (47)	9.3 (71)	0.0 (0)	
Terraced houses	Forest cover	59.4 (535)	7.9 (71)	24.2 (218)	8.5 (77)	100.0 (901)
	Potential for recreational use, summer	95.1 (857)	1.7 (15)	3.2 (29)	0.0 (0)	
	Potential for recreational use, winter	95.1 (857)	1.7 (15)	3.2 (29)	0.0 (0)	
Larger buildings	Forest cover	54.2 (128)	3.8 (9)	12.3 (29)	29.7 (70)	100.0 (236)
	Potential for recreational use, summer	84.3 (199)	7.2 (17)	8.5 (20)	0.0 (0)	
	Potential for recreational use, winter	84.3 (199)	7.2 (17)	8.5 (20)	0.0 (0)	

and areas with potential for recreational use. The residential buildings are divided into 4 groups; detached houses, semi-detached houses, terraced houses and larger buildings with apartments. Based on the critical distances for reaching a recreational area, four buffer zones outside the areas with potential for recreational use are produced; 'within 250 m, '250–300 m', '300–500 m' and '500–1000 m'. These buffer zones reflect the different thresholds for external access, affecting the frequency of use of recreational areas. The buffer analysis is carried out for all three mappings of areas with potential for recreational use (according to definitions A, B and C).

After the buffer zones are produced, the number of buildings from each housing category that falls within these buffer zones is calculated. Buildings that are located in the boundary between two buffer zones (for instance exactly 250 m from a recreational area) are counted as part of the inner buffer zone (in this example within the 250 m buffer zone).

Table 4 shows the results from the buffer analysis; the distribution of residential buildings of different categories within different distances to areas with potential for recreational use. It shows that residential buildings in Moss municipality generally have good external access to areas with potential for recreational use. None of the buildings are further away than 500 m from areas with potential for recreational use according to definitions B and C. Over 84% of the buildings for all housing categories are within 250 m from these areas. There is however a small tendency that detached and terraced houses are located closer to recreational areas than semi-detached houses and larger buildings with apartments. For the distances measured to areas with potential for recreational use according to definition A (forest areas), there are larger differences between the different housing categories. A larger proportion of the larger buildings with apartments are located between 500 m and 1000 m to forest areas than the case is for the other housing categories. This implies that there are differences regarding what types of recreational areas residents of different housing categories have access to. Residents in apartment buildings may have access to recreational areas of poorer quality than residents in detached, semi-detached and terraced houses. This information may be further utilized by planners and policy makers in Moss municipality, for instance by preventing that existing apartment buildings increase the distance to the nearest forest as a result of new development projects.

Although the areas with potential for recreational use in the winter months are considerably larger than the areas with potential in the summer months, the number of residential buildings within different distances to areas with potential for recreation in the winter does not differ notably from the results in the analysis of the summer map. This is probably because the agricultural areas in Moss are situated in the fringe areas of the municipality. However, the additional areas identified suggest that people have access to larger recreational areas in the winter months. Focusing solely on external access hides the question of the quality of the areas people have access to.

Performing the buffer analysis on the map of forest cover (definition A) has greater impact on the results. This analysis shows a clear tendency that detached houses are located closer to forest areas than the other housing categories, and that larger apartment buildings generally have longer distances to forests. This is a result of the map layer not including smaller recreational areas near or within the city centre. Nevertheless, also for this housing category over 54% of the buildings are located closer than 250 m to a forest.

To compare the results of a buffer analysis to a network analysis, both measurement methods were carried out for a recreational area in Moss called Mosseskogen, and the surrounding residential areas. The network analysis measured actual distance along existing roads, pedestrian paths and cycle paths between buildings in the residential areas and entrances to Mosseskogen. Before the actual distances from the residential buildings to the nearest entrance to Mosseskogen could be measured, the entrances to Mosseskogen were registered and digitized. Field analysis was conducted to locate the entrances. 17 points of entry, formal and informal, were registered. The entrances to Mosseskogen are shown in Fig. 6.

The road network (including pedestrian paths and cycle paths), were extracted from the map layer CMB 'road situation'. The connectivity in this network was poor, and manual connection was done with orthophoto as base.

Actual distance along the existing road- and path network between the four housing categories (detached houses, semi-detached houses, terraced houses and larger buildings) and the

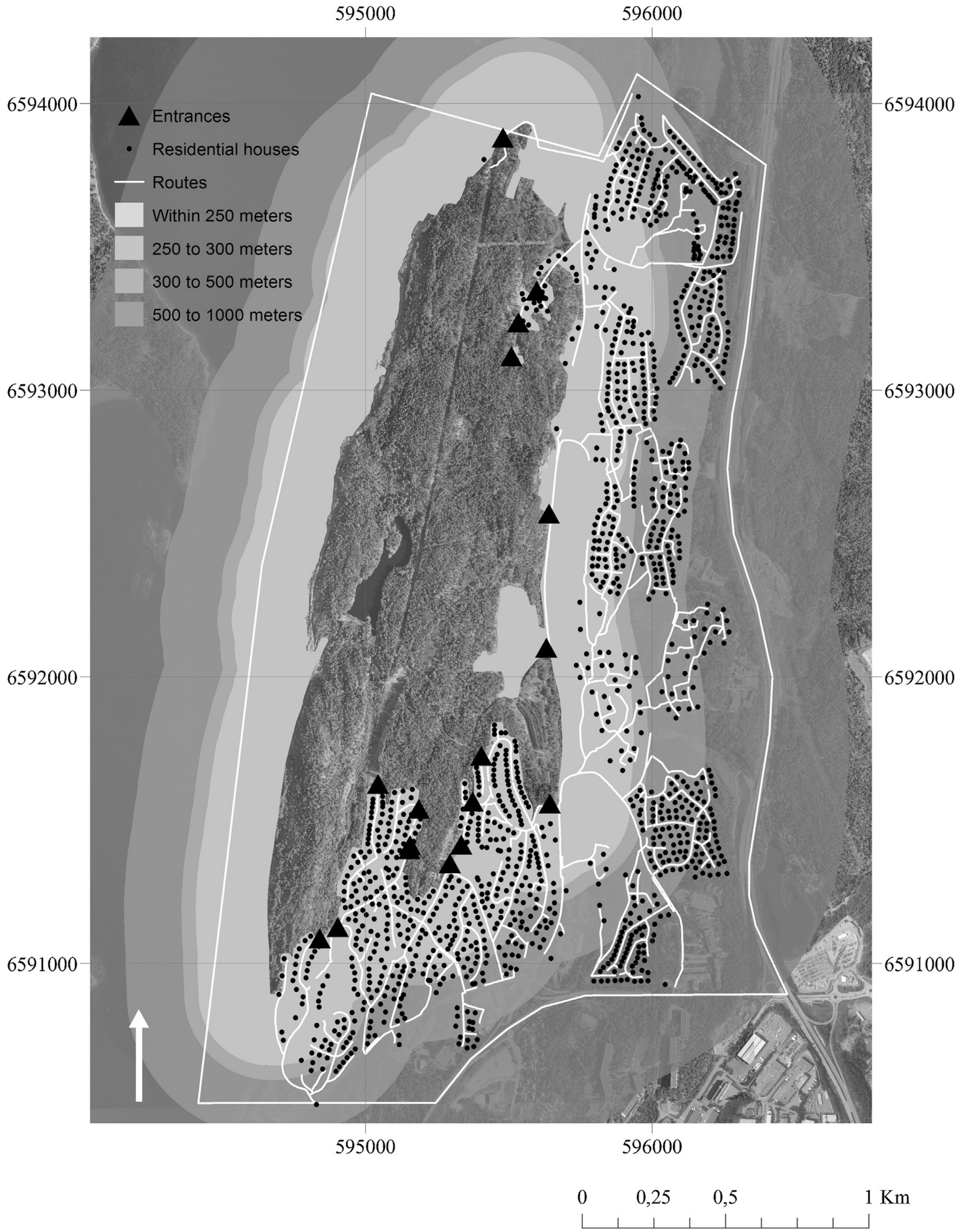

Fig. 6. Distribution of residential buildings within different buffer zones outside Mosseskogen, and the actual access routes leading towards entrances to the forest.

entrances to Mosseskogen were calculated using the 'closest facility' function in ArcGIS. The actual distances were summarized into the same distance categories as in the buffer analysis; within 250 m, 250–300 m, 300–500 m and 500–1000 m. In addition a fifth category was created; over 1000 m. Fig. 6 illustrates the distribution of housing categories within different buffer zones from Mosseskogen, as well as the road- and path network leading from each residential building to the nearest of 17 entrances.

Comparing the results from the buffer and the network analysis of distances from residential buildings surrounding Mosseskogen reveal large differences in distances for all housing categories (see Table 5). Looking into the results for the detached houses, we can see that the number of detached houses within 250 m of a recreational area is over twice as large according to the buffer analysis as according to the network analysis. In the buffer analysis only 12.6% of the detached houses were further away than 500 m. None of the detached houses were further than 1000 m from the forest. In comparison, nearly 60% of the detached houses are located further away than 500 m from the forest according to the network analysis, also including houses further away than 1 km.

Discussion

Measuring distance to recreational landscapes is often seen as a straight-forward linear process, as described in Fig. 1. However, as we have seen, the process covers a myriad of questions that need

Table 5
Distribution of housing categories within different distances to Mosseskogen, result from buffer analysis and network analysis (percentage and number of buildings).

Housing category	Measuring method	Within 250 m	250-300 m	300-500 m	500-1000 m	Over 1000 m	Total
Detached houses	Buffer analysis	49.8 (479)	8.9 (86)	28.6 (275)	12.6 (121)	0.0 (0)	100.0 (961)
	Network analysis	22.7 (218)	4.3 (41)	13.6 (131)	45.6 (438)	13.8 (133)	
Semi-detached houses	Buffer analysis	35.9 (33)	5.4 (5)	44.6 (41)	14.1 (13)	0.0 (0)	100.0 (92)
	Network analysis	14.1 (13)	2.2 (2)	17.4 (16)	46.7 (43)	19.6 (18)	
Terraced houses	Buffer analysis	28.7 (47)	15.9 (26)	45.7 (75)	9.8 (16)	0.0 (0)	100.0 (164)
	Network analysis	11.6 (19)	1.2 (2)	9.1 (15)	73.2 (120)	4.9 (8)	
Larger buildings	Buffer analysis	90.9 (20)	4.5 (1)	4.5 (1)	0.0 (0)	0.0 (0)	100.0 (22)
	Network analysis	31.8 (7)	9.1 (2)	22.7 (5)	36.4 (8)	0.0 (0)	

to be answered before and during the analysis. Choices are made in three main steps, defining and mapping recreational landscapes, identifying who we are measuring distance for, and choosing the appropriate methods for measuring distance.

In step 1, when defining and mapping recreational landscapes, one needs to consider which types of recreational areas that are of interest. The distance in itself is of little interest if we are not clear about what we are measuring distance *to*. How we define a recreational landscape, and what land cover categories we choose to include in the mapping of these areas, depends upon our view of recreational activity. In a traditional Norwegian context, a narrow definition of outdoor recreation limits recreational activity to 'hiking in the forest'. With this definition of recreational activity, mapping of the forested areas is satisfactory. Hörnsten and Fredman (2000), Arnberger (2006), Ode and Fry (2006), De Clercq et al. (2007), Gundersen and Frivold (2008) and Colson et al. (2010) focus solely on forests as areas for recreational activity. If the purpose of the mapping is to identify areas important in a public health perspective, areas suitable for a wider range of recreational activities should be included. In addition to forested areas, Caspersen and Olafsson (2010) and Schipperijn et al. (2010) include other types of green space, for instance beach- and lake areas, parks, and other open natural areas.

What types of recreational areas that are of interest is also related to the question of who we are measuring access for. For instance, when mapping and measuring external access for children, small recreational areas within residential areas are important to include. The threshold of 5000 m^2 as a minimum size for recreational areas, may be problematic as it omits a large number of small green spaces that can be of great importance to physical activity for children (Fjørtoft and Sageie, 2000). For adult user groups these small areas may be of little interest. In a public health perspective it is important to apply a broad definition of recreational landscapes in order to include all areas that are important for everyday outdoor recreation, also areas that are important to user groups that are less mobile than the general public, for instance children and elderly.

In our study, different definitions of recreational landscapes resulted in a variation of areas identified as having potential for recreational use. The mapping of areas with potential for outdoor recreation did not take into account the visual and functional landscape qualities of the areas, and areas mapped within the same definition will vary when it comes to landscape quality. Also, areas with good landscape qualities located further away might be preferred over areas with poor landscape qualities close by, and large areas located further away might be preferred over small areas close by. This depends upon the purpose of the visit, and whether the planned activity is an area demanding activity.

The application of specific definitions of what constitutes a recreational area affects the amount of areas identified and also their spatial distribution. Using a definition that does not cover all areas of interest for outdoor recreation, one risks losing important recreational areas in a development process. This can be particularly severe to areas of importance to children, as these can seem insignificant from an adult's perspective, and as children rarely have access to direct participation in planning and decision-making.

In step 2 we defined who or what we were measuring accessibility to recreational areas for. We chose to base our analysis on housing data, and divided the housing data into 4 categories, as found in the dataset; detached houses, semi-detached houses, terraced houses and larger buildings with apartments. Using housing data, it is possible to analyze if there are inequalities in accessibility between residents of different housing categories. Using population survey data, it is possible to measure access for the general public, or to divide the population into user groups, for instance based on age, and study how the external accessibility is for these groups. Neuvonen et al. (2007) divides the population into user groups based on gender, age, education and status of employment. This makes it possible to study how accessibility is distributed according to these variables. A common problem is that access to and use of population survey data is restricted due to issues of privacy. Planners and policy-makers lacking information of where large numbers of children or elderly are living, may lead to small recreational 'patches' within residential areas, important to these user groups, being overlooked and possibly lost in planning processes.

In step 3 we explored the two main methods for measuring distance within a GIS environment; buffer analysis and network analysis. Both measurement methods demanded a clarification of which critical distances, or thresholds, that is relevant to use. If the purpose of an analysis is to measure distance for people of *all* age groups, the threshold should be set to a distance that also children and elderly are able to walk in about 10 min. The critical distances we used in our analysis are derived from recommendations from the Nordic Council of Ministers (1996) and the Norwegian Institute of Public Health (2009). We found considerable differences in the distances measured when comparing the results from the buffer and the network analysis. Our study illustrate how external access measured as metres of actual distance rather than linear distance

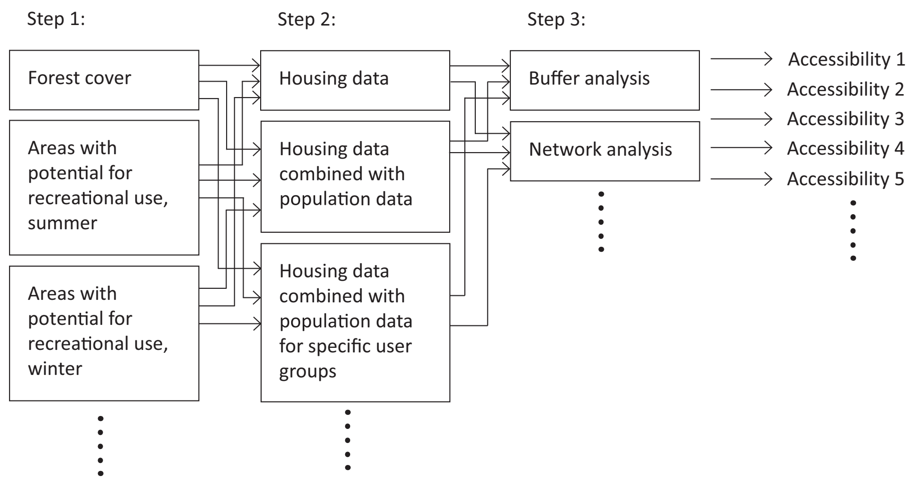

Fig. 7. Different ways to manage through the steps in mapping and measuring accessibility to recreational landscapes, and different possible results of the process.

reduced the number of homes within different distance thresholds from areas with potential for recreational use, probably giving a more accurate expression of people's perceived accessibility. The comparison of buffer and network analysis makes it apparent that distance is highly affected by infrastructure. Network analysis provides a more realistic picture of the distances people have to walk to reach their nearest recreational area. Hörnsten and Fredman (2000) and Neuvonen et al. (2007) explicitly clarifies that the distances they assess are the walking distances.

Both buffer and network analysis have advantages and disadvantages. Buffer analysis does not capture the barriers people can meet on the way to their nearest recreational area. Measuring distance from a residential house, via existing infrastructure (roads and pathways), to an entrance to recreational area, gives a more realistic measurement of the distance a person has to walk to reach a recreational area. Network analysis is however more labour-intensive, and often requires field work for registration of entrances. Network analysis also places greater demands on the data quality, and checking the connectivity in the road- and path network may involve considerable manual work. Network analysis is therefore more challenging to implement for an entire municipality. Due to limited resources in terms of data sources, time, economy and skills of the people conducting the analysis it may be necessary to settle for a buffer analysis on a regional level. One must however be aware that the choice of method for measuring distance may have major impact on the results of the analysis. If planners and policy-makers do not have a network perspective, they will have inaccurate information of the distances people have to walk to reach a recreational area. In a planning process, a decision to develop a new area may lead to loss of entrances or breaches in path networks. A transparent, adequate and accurate analysis is essential in order to avoid deterioration of people's access to recreational areas.

As we have seen when mapping and measuring accessibility to recreational landscapes in Moss municipality, the result that derives from our analysis is highly affected by how we conduct our analysis. Fig. 7 illustrates how the combination of choices made in the different steps of the analysis makes several possible outcomes and representations of the situation regarding access to recreational landscapes. The purpose of the analysis must be decisive for the choices made within the three steps, to provide planners and policy-makers with the best possible basis for decisions regarding urban green structure.

When making choices following the three steps, the content and the quality of the data sources need to be taken into account. It is in the structure of GIS that analysis are conducted on fixed categories, and this affects what can be studied, and the results derived from the analysis. In addition to available data sources, resources in terms of time, economy and skills of the people conducting the analysis will limit the range of possible choices made. Because of limited resources, choosing the 'ideal' path towards the most relevant results is often difficult.

While this study has focused on the mapping of access, it is desirable to link this with information on the residents' actual demand for outdoor recreation, their present use of recreational areas as well as their perceived accessibility to recreational landscapes. This could provide planners and policy-makers with a better picture on the present accessibility to recreational landscapes and contribute to an increased understanding of the mechanisms in people's choice for recreational landscapes.

Conclusion

If accessibility to recreational landscapes is measured without reflecting on different definitions of recreational landscapes, the people we are measuring distance for and types of measuring methods, the results of the measurement are less suitable to base political decisions on. Numbers and maps are powerful representations of 'reality', but without knowing how they are produced, it is problematic if they are perceived as 'facts'. The choices made when mapping and measuring accessibility to recreational landscapes must be transparent to planners and policy-makers making decisions based on the measurements. Planners and policy-makers need to take into account the premises for the measurements conducted. The methods applied must also be adequate with regard to the purpose of the analysis.

In a public health perspective, different types of recreational areas are of importance for different user groups. For instance, when mapping and measuring accessibility for children, it is important to include small recreational areas within residential areas. On the other hand, when measuring accessibility for adult user groups with good mobility, these areas could however be excluded. For elderly and other groups with reduced mobility, parks and other facilitated recreational areas are especially important when analysing access and need to be included, while areas less facilitated might need to be excluded. When looking at the distribution of access to recreational landscapes within a local municipality it could be beneficial to use population survey data when calculating distance measurements and defining recreational landscapes. This makes it possible to analyze who and how many that have good as well as poor access to recreational areas. However, since population survey data are generally more restricted in their access, this might not be possible within all circumstance. A substitute that provides some information related to socio-economic situation could be the use of housing data. Housing data may also be useful when planning and designing new development areas, to secure that these areas are located within a certain proximity to recreational areas and to secure that accessibility for residents in existing residential areas is not reduced. When analysing distance, there is mainly two options available; buffer analysis or network analysis. If resources in terms of data sources, time, economy and skills of the people conducting the analysis are present, network analysis is preferred over buffer analysis since. The result from the network analysis provides a more realistic picture of the distances people have to walk to reach their nearest recreational area compared to the buffer zones. However, the network analysis has higher demands when it comes to data sources (including high demands on the quality of the path and road network and notion of entrances to areas), time, economy and skills of the people conducting the analysis and might therefore not be feasible in most circumstances.

Planners and policy-makers facing the pressures of urban development, and at the same time aiming to promote outdoor recreation for public health reasons, depend on appropriate measurements of accessibility in order to make informed decisions when choosing between different scenarios in planning processes. Adequate measurements of citizens' perceived access to recreational landscapes can also support planners and policy-makers in taking positive action to increase people's accessibility, for instance by obtaining new entrances, highlighting existing entrances or removing barriers. Enhanced understanding of how people perceive access to recreational landscapes and finding the appropriate ways to integrate this in planning and decision-making processes is essential in safeguarding the potential for outdoor recreation through careful management of urban green structure.

References

Arksey, H., O'Malley, L., 2005. Scoping studies: towards a methodological framework. International Journal of Social Research Methodology 8 (1), 19–32.

Arnberger, A., 2006. Recreation use of urban forests: an inter-area comparison. Urban Forestry & Urban Greening 4 (3-4), 135–144.

Caspersen, O.H., Olafsson, A.S., 2010. Recreational mapping and planning for enlargement of the green structure in greater Copenhagen. Urban Forestry & Urban Greening 9 (2), 101–112.

Chrisman, N., 2002. Exploring Geographic Information Systems, 2nd ed. John Wiley & Sons Inc., New York.

Colson, V., Garcia, S., Rondeux, J., Lejeune, P., 2010. Map and determinants of woodlands visiting in Wallonia. Urban Forestry & Urban Greening 9 (2), 83–91.

Comber, A., Brunsdon, C., Green, E., 2008. Using a GIS-based network analysis to determine urban greenspace accessibility for different ethnic and religious groups. Landscape and Urban Planning 86 (1), 103–114.

Costa-Font, J., 2008. Housing assets and the socio-economic determinants of health and disability in old age. Health & Place 14 (3), 478–491.

Dahmann, N., Wolch, J., Joassart-Marcelli, P., Reynolds, K., Jerrett, M., 2010. The active city? Disparities in provision of urban public recreation resources. Health & Place 16 (3), 431–445.

De Clercq, E.M., De Wulf, R., Van Herzele, A., 2007. Relating spatial pattern of forest cover to accessibility. Landscape and Urban Planning 80 (1-2), 14–22.

De Ridder, K., Adamec, V., Bañuelos, A., Bruse, M., Bürger, M., Damsgaard, O., Dufek, J., Hirsch, J., Lefebre, F., Pérez-Lacorzana, J.M., et al., 2004. An integrated methodology to assess the benefits of urban green space. Science of the Total Environment 334–335, 489–497.

Dramstad, W.E., Fry, G., Fjellstad, W.J., Skar, B., Helliksen, W., Sollund, M.L.B., Tveit, M.S., Geelmuyden, A.K., Framstad, E., 2001. Integrating landscape-based values – Norwegian monitoring of agricultural landscapes. Landscape and Urban Planning 57 (3-4), 257–268.

Emmelin, L., Fredman, P., Lisberg Jensen, E., Sandell, K., 2010. Planera för friluftsliv – natur, samhälle, upplevelser (Planning for Outdoor Recreation – Nature, Society, Experiences). Carlsson Bokförlag, Stockholm.

Engelien, E., 2012. Tilgang til rekreasjonsareal og nærturterreng. Dokumentasjon av metode (Access to areas for outdoor recreation and close-to-home recreation. Documentation of method). Statistics Norway.

Evans, J.M.M., Newton, R.W., Ruta, D.A., MacDonald, T.M., Morris, A.D., 2000. Socioeconomic status, obesity and prevalence of Type 1 and Type 2 diabetes mellitus. Diabetic Medicine 17 (6), 478–480.

Fjørtoft, I., Sageie, J., 2000. The natural environment as a playground for children: landscape description and analyses of a natural playscape. Landscape and Urban Planning 48 (1–2), 83–97.

Geurs, K.T., van Wee, B., 2004. Accessibility evaluation of land-use and transport strategies: review and research directions. Journal of Transport Geography 12 (2), 127–140.

Gobster, P.H., 1995. Perception and use of a metropolitan greenway system for recreation. Landscape and Urban Planning 33 (1–3), 401–413.

Grahn, P., 1994. Green structures – the importance for health of nature areas and parks. European Regional Planning 56, 89–112.

Grundy, E., Sloggett, A., 2003. Health inequalities in the older population: the role of personal capital, social resources and socio-economic circumstances. Social Science & Medicine 56 (5), 935–947.

Gundersen, V.S., Frivold, L.H., 2008. Public preferences for forest structures: a review of quantitative surveys from Finland, Norway and Sweden. Urban Forestry & Urban Greening 7 (4), 241–258.

Hartig, T., Mang, M., Evans, G.W., 1991. Restorative effects of natural environment experiences. Environment and Behavior 23, 3–27.

Hörnsten, L., Fredman, P., 2000. On the distance to recreational forests in Sweden. Landscape and Urban Planning 51 (1), 1–10.

Jim, C.Y., Chen, W.Y., 2006. Recreation-amenity use and contingent valuation of urban greenspaces in Guangzhou, China. Landscape and Urban Planning 75 (1–2), 81–96.

Jørgensen, K., Thorén, K.H., 2012. Planning for a Green Oslo. In: Luccarelli, M., Røe, P.G. (Eds.), Green Oslo: Visions, Planning and Discourse. Ashgate, Farnham.

Mann, C., Pouta, E., Gentin, S., Jensen, F.S., 2010. Outdoor recreation in forest policy and legislation: a European comparison. Urban Forestry & Urban Greening 9 (4), 303–312.

Neuvonen, M., Sievänen, T., Tönnes, S., Koskela, T., 2007. Access to green areas and the frequency of visits – a case study in Helsinki. Urban Forestry & Urban Greening 6 (4), 235–247.

Nordic Council of Ministers, 1996. Friluftsliv trenger mer enn arealer - en studie av kriterier og normer for friarealer i kommunal planlegging (Outdoor recreation demands more than areas - a study of criteria and norms for recreational areas in municipal planning). TemaNord 591, Copenhagen.

Norwegian Institute of Public Health, 2009. Miljø og helse – en forskningsbasert kunnskapsbase (Environment and Health – A Research-based Knowledge Base).

Norwegian Ministry of the Environment, 1993. Den regionale planleggingen og arealpolitikken (Regional Planning and Spatial Policy). Ministry of the Environment, Oslo.

Ode, Å., Fry, G., 2006. A model for quantifying and predicting urban pressure on woodland. Landscape and Urban Planning 77 (1–2), 17–27.

Pate, R.R., Pratt, M., Blair, S.N., Haskell, W.L., Macera, C.A., Bouchard, C., 1995. Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. Journal of the American Medical Association 273 (5), 402–407.

Pretty, J., Peacock, J., Sellens, M., Griffin, M., 2005. The mental and physical health outcomes of green exercise. International Journal of Environmental Health Research 15 (5), 319–337.

Schantz, P., 2003. Fysisk aktivitet och hälsa kräver goda miljöer. Vilka er de och hur skapas de? (Physical activity and public health demands good environments. Where are they and how are they created?). Svensk Idrottsforskning 1, 6–11.

Schipperijn, J., Ekholm, O., Stigsdotter, U.K., Toftager, M., Bentsen, P., Kamper-Jørgensen, F., Randrup, T.B., 2010. Factors influencing the use of green space: results from a Danish national representative survey. Landscape and Urban Planning 95 (3), 130–137.

Skov-Petersen, H., Goossen, M., 2009. Assessing and planning the supply of opportunities for forest recreation. In: Bell, S., Simpson, M., Tyrväinen, L., Sievänen, T., Pröbstl, U. (Eds.), European Forest Recreation and Tourism. Taylor, Francis, pp. 134–148.

Statistics Norway, 2011. Population per 1 October 2011 and Population Changes During 3rd Quarter of 2011 Østfold. http://www.ssb.no/a/english/kortnavn/folkendrkv_en/tab-2011-11-17-01-en.html

Stokke, K.B., Falleth, E.I., 2010. Bevaring av bynære friluftsområder – hva betyr deltakelse og mobilisering fra lokalsamfunnet? (Preservation of urban recreational areas – the role of mobilization from the civil society). Kart og Plan 4, 265–276.

Thorén, K.H., 2000. "The green poster" A method to evaluate the sustainability of the urban green structure. Environmental Impact Assessment Review 20 (3), 359–371.

Van den Berg, A.E., Maas, J., Verheij, R.A., Groenewegen, P.P., 2010. Green space as a buffer between stressful life events and health. Social Science & Medicine 70 (8), 1203–1210.

Van Herzele, A., Wiedemann, T., 2003. A monitoring tool for the provision of accessible and attractive urban green spaces. Landscape and Urban Planning 63 (2), 109–126.

Velarde, M.D., Fry, G., Tveit, M., 2007. Health effects of viewing landscapes – landscape types in environmental psychology. Urban Forestry & Urban Greening 6 (4), 199–212.

World Health Organization, 2010. Global Recommendations on Physical Activity for Health. Geneva.