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Balancing landscape-level forest management between recreation and wood production

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ABSTRACT

Although many forested landscapes are used for both wood production and outdoor recreation, intensive forest management can negatively impact the recreational value of forests, including in Sweden, a country with rich forest resources and a strong forest industry. In Sweden, urbanization has increased the importance of, and demand for, urban and peri-urban recreational green areas such as forests. It is the responsibility of the local government – i.e., the municipalities – to provide a good living environment for its inhabitants, including recreational areas. However, most of the forest areas in Sweden are owned by private individuals and companies, which have a large degree of freedom in their forest management decisions. Municipalities can make formal agreements with forest owners to protect forests with high recreational values, but this requires financial resources, which are often scarce. Thus, tools are needed to identify the forest areas that should be prioritized for the use of forest management strategies that maintain or increase the recreational value of forests. In this study, we elaborate an approach that balances economic and recreational forest values within a forest decision support system (DSS) and test the approach for a case study area in southern Sweden. The recreation model included in the forest DSS links locational aspects, such as population density and proximity to water, with forest structure aspects, which are simulated over time under different management strategies. Our results suggest that the model could be useful for more efficient planning of the recreational potential of forests at the landscape level. The results from the case study indicate that substantial increases in the recreational value of a forest landscape can be achieved with relatively small overall economic losses, for example, by extending rotation periods in forests close to densely populated areas.

1. Introduction

The importance and use of forests for recreational activities has been frequently recognized (Eriksson et al., 2012; Konijnendijk, 2003; Lindhagen, 1996; Olsson, 2013), and efforts are made to implement recreational and scenic values in forest planning, management, and governance (Mattila et al., 2015; Sténs et al., 2016). In Sweden and other Nordic countries, forest recreation is very popular, has a long tradition and is part of a sense of national identity (Vistad et al., 2010). At the same time, wood production continues to be an important economic activity in many forest-rich countries, including Sweden, and is likely to remain strong because of the expected increases in biomass demand due to demographic trends and the rise of a bio-based economy (Beland Lindahl and Westholm, 2010). Unfortunately, intensive forest management for wood production is often in conflict with recreational forest values (Kangas et al., 2008), as numerous studies have shown that people in general prefer mature forests with good visibility and little or no obvious signs of human interventions, such as large clear-cuts, residues from felling activities, and ground damage (Gundersen and Frivold, 2008). Most forest visits take place close to where people live. In Sweden, 85% of the population lives in cities or urban areas (Olsson, 2013), a demographic trend that emphasizes the important role of urban and peri-urban forests for recreation. Even though urban woodlands are still common in Sweden, a lack of legal protection and continuing urbanization may lead to the loss and further fragmentation of these woodlands, particularly in urban areas with an expected population increase (Hedblom and Söderström, 2008). Ultimately, it is the municipalities' responsibility to consider the demand for and supply of recreational areas in their planning (SFS, 2010; Swedish Ministry of Finance, 2004). Most Swedish municipalities own some urban forest land, however, a large share of urban and peri-urban forests is owned by private individual owners and private forest companies (Olsson,

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2013). Although all forests in Sweden are accessible to everybody for recreation under the Right of Public Access (Swedish Environmental Protection Agency, 2017), their attractiveness for recreational activities largely depends on the management choices of the forest owners. Forest-related legislation (SFS, 1979) and other governance instruments, such as certification and the national objectives for outdoor recreation (Regeringen, 2012), require forest owners to consider recreation in their management decisions. Nevertheless, forest owners have a large degree of freedom in their management decisions, and forest policy objectives are mainly pursued through information, advice, and recommendations. Although private forest owners in general feel a responsibility for social values, including recreation, their knowledge of such values and how to enhance them in forest management is perceived as low according to a self-assessment of private forest owners (Bjärstig and Kvastegård, 2016). The need to safeguard privately owned forest with high recreational value is reflected in a newly implemented policy that allows landowners to make voluntary agreements to protect forests with high recreational values and provides compensation for missed income from harvesting (Swedish Forest Agency, 2014). However, money set aside for compensation is often scarce, and exempting wood production from all forests with high recreational value is not a viable strategy. Instead, it is important to find site-specific management strategies that balance wood production with recreational value over time and to identify forests where adapted management should be used to maintain or increase the recreational value of forest areas. Thus, efficient planning requires tools that assess the impact of management strategies on the recreational value of forests and economic value of wood production and that identify management strategies that succeed in balancing economic and recreational values. Such tools could be useful for the planning of municipalities' own forests as well as for identifying which forest owners should be approached to maintain and develop high quality recreational areas for the municipalities' inhabitants.

The objective of this study was to develop and test an approach that balances economic and recreational values in a forest landscape by strategically distributing different forest management strategies throughout the landscape. We aimed for a method that should be able to identify forest areas to prioritize for recreation, suggest suitable management alternatives in such areas and be useful in communication processes with forest owners. The developed approach builds on a model that calculates the recreational value of the forest landscape in a forest decision support system (DSS). This model combines two important aspects that define the recreational value of the forest: locational aspects such as population density in the vicinity and stand-based forest structure aspects. In the DSS, alternative developments of the stand-based forest structure aspects are simulated over time under different management strategies. Next, a set of mixed integer optimization models strategically distributes the management strategies throughout the landscape for different levels of consideration for recreation. The model was tested on a landscape in southern Sweden of almost 14 000 ha of productive forest area. The following sections describe the method for calculating the recreation index, the applied forest DSS, and the case study.

2. Methods

2.1. Landscape recreation index

A **landscape recreation index** was calculated by multiplying a location index and a forest stand index (Eq. (1)). While the location index was assumed to be constant over time (i.e., no change in population density or location), the forest stand index changes over time subject to stand development and forest management:

$$R_p = \mathrm{L}^* S_p \quad (1)$$

where R_p is the landscape recreation index for period p, L is the location index, and S_p is the forest stand index for period p. All indices in Eq. (1) were calculated on the stand level.

The **location index** is based on an expert model and gives a value between 0 and 1, where a value close to 1 indicates that the forest stand is potentially very valuable for recreation for a large population as it is close to urban areas. The most important factors in the model are the number of people living within 300 m and number of people living between 300 m and 2000 m. Earlier studies have shown that there is a negative correlation between visiting frequencies and the distance to the closest recreational forest (Hörnsten, 2000). 250–300 m was identified as a critical walking distance to recreational areas during weekdays (Nordisk ministerråd, 1996), and 300 m is also the preferred median distance to the closest recreational forest according to a survey conducted in Sweden (Hörnsten and Fredman, 2000). Visiting frequencies drop notably when the distance exceeded 2000 m (Hörnsten, 2000). The distances included in the function correspond with shorter forest visits made during weekdays and weekends. More long-distance forest visits are a small proportion of the number of total forest visits and are not included in this function. The model also includes a positive effect of proximity to water, as water bodies increase the value for recreation and rehabilitation (Hannerz et al., 2016; Nordström et al., 2015), and a negative effect of noise disturbances caused by major roads. The location index is calculated as follows:

$$\mathrm{L} = 1 - e^{-(0.01x + 0.001y + 0.15v - 0.15r)} \quad (2)$$

where x is the population within 300 m from the stand, y is the population within between 300 and 2000 m from the stand, v is the presence of open water within 50 m from the stand (dummy), and r is the presence of a major road within 100 m from the stand (dummy).

The **forest stand index model** was developed using visual interpretation of a long range of forest variables in photographs that were included in surveys of recreational preferences made in Sweden and Denmark during the 1990s (Hörnsten, 2000; Koch and Jensen, 1988; Lindhagen, 1996). Stepwise regression was used to assess the impact of the interpreted forest variables on the values for outdoor recreation suitability that were obtained among the adult population. The work resulted in three different linear functions to be used in forests of different heights: one for bare land and very young forests, one for young forests, and one for mature forests (Table 1). The function applied is regulated by the mean tree height of the stand where each function applies to a certain height interval. For a smooth transition between the functions, results are weighted when the height is in the transition zone between two functions (> 1–3 m and > 12–16 m).

The functions result in index values between 0 and 1, with higher index values indicating higher suitability for recreation. The functions are subject to various variables, whose parameter values are given in Table 1. For bare land and newly regenerated forests (Function 1), index values increase with increased tree size diversity, while the occurrence of deadwood or harvest residues decrease index values. For young stands (Function 2), in addition to the above, increased conifer proportion decreases index values, i.e. broadleaves are preferred. For older stands (Function 3), there are additional variables for the number of stems (many large trees are preferred over small trees) and soil damage (the occurrence of soil damage from e.g. thinning operations has a negative impact on index values).

The developed functions conform with results from other studies on public preferences for forest structures, which have shown that stand age or phase of development are very important for recreational values (Edwards et al., 2012a,b), with tree size being positively correlated with recreational value (Gundersen and Frivold, 2008 and references therein). Large fresh clear-cuts are disliked by the majority of forest visitors, while seed or retention trees can improve people's perception of a felling site (Gundersen and Frivold, 2008; Rydberg and Falck, 2000). Consequently, the intercept for bare land or newly regenerated forest (Function 1) is low (0.3), which means that these forests receive a low stand index, which can only be increased if these stands have an