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Research Paper

Producing a sensitivity assessment method for visual forest landscapes

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HIGHLIGHTS

- A method and a model were developed to assess the sensitivity of visual forest landscapes.
- In the case study a sensitivity classification for a land area of more than 27 000 km^2 was produced.
- The most sensitive areas are located in high places and experience intensive outdoor recreation use.
- Sensitivity values estimated by the model are quite similar to values calculated from expert opinions.

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ABSTRACT

A landscape sensitivity index provides information about the location of the most sensitive forest areas in terms of visual alteration. This information is needed to recognize those areas which require special attention in terms of management policy decisions and in directing landscape management activities and subsidies. The main goal of this study was to develop and test a GIS-based method to enable the production of a sensitivity index map on a regional scale. To accomplish this, sensitivity criteria, a model and calculating techniques were developed for the landscape province of the Kainuu and Kuusamo hill area in Finland. Sensitivity was described using three main criteria: (i) visibility, (ii) the amount of potential users (use pressure) and (iii) the attractiveness of the landscape – which are further defined by several sub-criteria. The calculation method was based on spatial multicriteria evaluation (SMCE), where cartographic modeling and expert knowledge modeling are utilized. The method was demonstrated and tested by a case study, where a visual landscape sensitivity map was produced for one municipality in the selected landscape province. The results were evaluated by forest and environment experts. The evaluation process showed that the sensitivity values estimated by the sensitivity model were quite similar to the values calculated from the expert map and field evaluations.

1. Introduction

The quality of the visual landscape is important not only to individual citizens and their health and well-being (Richardson et al., 2012; van Dillen, de Vries, Groenewegen, & Spreeuwenberg, 2012), but also to the livelihood of rural areas. Landscapes are the central attraction in nature-based tourism, and an appealing landscape can attract other livelihoods and new residents to rural areas. Some 52% of Finnish forestry land is owned by private forest owners and 35% by the state (Finnish Statistical Yearbook of Forestry, 2012). Private forest owners appreciate the landscape provided by their forests. Around 20–30% of them emphasize the recreational and scenic values in their forest ownership (Karppinen, 1998a, 1998b), and 40% have areas in their forests that they will not fell because of the scenic values (Hänninen & Kurttila, 2007). Legislation has imposed general societal obligations on Metsähallitus (the authority responsible for the care of state forests), which include the responsibility for promoting outdoor recreation. Finland has also ratified the European landscape convention, which commits the authorities to protect, plan and manage landscapes.

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While the majority of the forest area is used for timber production, there is a need to map areas where special attention should be paid to strategic and operative planning because of their sensitivity to visual alteration such as forest fellings. In Finland, the forestry organizations often have information and databases on the locally valuable forest stands and small-scale destinations. However, until now forestry professionals and forest owners have not had enough knowledge to support their decision-making in terms of the visibility and scenic attractiveness of specific forest areas on a regional scale. Thus, equal attention is paid to forest landscape management everywhere, despite the visual sensitivities of the various places concerned. However, it would be more appropriate both scenically and economically to identify the visually sensitive areas and to focus landscape management activities on these areas.

The term *landscape sensitivity* has been used to indicate geomorphic sensitivity, which means how geomorphic systems respond to environmental change such as erosion, increasing temperature, winds and storms, or human activity (Harvey, 2001). It can imply both resilience to change and the ability to recover from change. *In forest landscape planning, the concept of landscape sensitivity or visual sensitivity is often defined as the resilience or fragility of the visual forest landscape to changes, such as altering land-use or forest fellings* (Forest Landscape Design Guidelines, 1994; Visual Landscape Inventory, 1997). Landscape sensitivity can be defined as the likelihood that implementing forestry practices or other activities would evoke criticism and concern from the public (Visual Landscape Inventory, 1997).

In some countries, landscape sensitivity is assessed as a part of forest landscape design or the forest management planning process (Bell, 1998; Landscape Aesthetics, 1995; Visual Landscape Inventory, 1997; Visual Resource Management, 2013). Landscape sensitivity can be used either as such in the planning or in determining scenic classes, which in turn are utilized to address the visual values in management planning. The terms used, the variables and targets assessed and the methods all vary, but the key concepts of the sensitivity assessments are: (1) visibility and distance zones from viewing points, (2) types and amount of use, (3) scenic attractiveness and quality, and (4) viewers' experiences.

Common to these landscape design methods (Bell, 1998; Landscape Aesthetics, 1995; Visual Landscape Inventory, 1997; Visual Resource Management, 2013) is that they are developed for large-scale landscapes, they often concern only specific areas, and they require different types of expert assessments, visitor surveys and other fieldwork. These models cannot be directly applied to Finnish conditions because the character of forest landscapes, the use of forests, and the prerequisites for this type of work differ. In Finland, viewing distances are relatively short and within-forest views are common, and it is not possible to use a lot of expert assessment and other fieldwork. In Finland, there is a need for a cost-efficient, robust, repeatable and automated landscape sensitivity assessment method that would be suitable for the whole country and that could be updated easily. The method should produce information about the location of the most sensitive forest areas for visual alteration at the regional level, i.e., to recognize areas that require special attention in the strategic and operative forest management planning and decision-making of forest owners. Sensitivity information is also needed in decisions concerning management policy, and in directing landscape management activities and subsidies.

When formulating a sensitivity assessment task as a form of a formal decision model, the real world situation has to be simplified, as is the case with any other modeling task. However, there are several different criteria that have an influence on landscape sensitivity and have to be taken into consideration in calculations. In this kind of circumstance, multi-criteria evaluation (MCE) can be used to help gather the information together to support the decision and to combine the evaluation criteria in a commensurable way (e.g., Kangas, Kangas, Leskinen, & Pykäläinen, 2001). The MCE methods provide a basis for evaluating a number of alternative choices on the basis of multiple criteria (Nijkamp, Rietveld, & Voogd, 1990). With the help of MCE, it is also possible to combine decision criteria measured in different measurement units, such as money and hectares on a common utility scale.

Geographic information system (GIS) applications have been adopted by suitability assessment concerning large areas (e.g., Carver, 1991; Jankowski, 1995; Siddiqui, Everett, & Vieux, 1996; Store, 2009; Store & Kangas, 2001). GIS is used for producing the data needed in evaluations and for a platform of calculations. GIS-based multi-criteria evaluation, sometimes called spatial multi-criteria evaluation (SMCE), has some advantages compared to traditional MCE, e.g., the Analytical Hierarchy Method (AHP) described by Saaty (1980), because with SMCE it is possible to analyze a huge amount of alternatives. In other words, when AHP is meant to analyze the performance of a few decision alternatives, it is also possible to use modified MCE approaches that enable the comparison of basically an infinite number of decision alternatives. In the MCE literature, one refers to discrete choice problems and continuous problems (e.g., Jankowski, 1995).

Because the criteria of landscape sensitivity are not necessary equally important, a sensitivity model with appropriate weights assigned to different criteria has to be developed. In situations where objective information and applicable models based on empirical data are inadequate or unavailable, it is possible to use expert knowledge modeling. Methods and techniques for utilizing expert knowledge in handling natural resources have been developed and used in forestry, for example (Alho & Kangas, 1997; Alho, Kangas, & Kolehmainen, 1996; Kangas, Karsikko, Laasonen, & Pukkala, 1993; Kangas, Store, Leskinen, & Mehtätalo, 2000; Store & Kangas, 2001).

The goal of the present study is to develop a landscape sensitivity assessment method that is suitable on a regional scale. For this purpose, the special aims are: (1) to compile the criteria and model for the landscape sensitivity assessment to one landscape province in Finland, and (2) to develop and test a new GIS-based method whereby it is possible to calculate a sensitivity index map for a visual landscape. The method is demonstrated and tested through a case study, where a landscape sensitivity map is produced for one municipality in the selected landscape province and the results are evaluated by forest and environment experts.

2. Study area

Landscape features differ in different parts of Finland to the extent that it is not possible to assess the landscape sensitivity for the whole country based on the exact same criteria or model. In Finland, the country is divided into 10 landscape provinces, parts of which are further divided into different regions (Maisemanhoito, 1992; Fig. 1). Landscape provinces provide a good starting point for developing the sensitivity criteria. The landscape provinces have been determined based on the significant natural features and their variability, such as landforms, soil, vegetation, as well as on the cultural characteristics of rural landscapes, while city landscapes have not been paid attention to.

The landscape province of the Kainuu and Kuusamo hill area was selected for this study to produce the sensitivity model because it includes a variety of landscape elements, such as variability in topography, a lot of lakes and watercourses, forests, mires and field areas. Besides permanent settlements, there are also a lot of second homes and tourist destinations. Because of the abundance of landscape features and different types of landscape users, it can be assumed that the sensitivity criteria developed for the Kainuu