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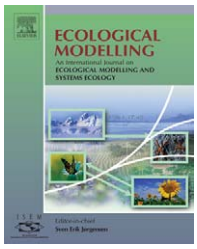

Habitat quality assessment using Weights-of-Evidence based GIS modelling: The case of *Picoides tridactylus* as species indicator of the biodiversity value of the Finnish forest

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ABSTRACT

Biodiversity issues have gained importance in forestry as a result of the increased awareness of forest landscape changes, but still there is much to do before forest management meets reasonable goals for forest protection and renewal of biodiversity. In this work, we focus on boreal forest landscapes, using Finland as a case study, and taking advantage of a valuable database—the National Forest Inventory (NFI). We explore a multicriteria approach by using a predictive habitat suitability model for three-toed woodpecker (*Picoides tridactylus*) based on Weights-of-Evidence (WofE) and a combination of remote sensing and field data derived from the Multisource Finnish National Forest Inventory (MS-NFI). The WofE model is a quantitative method used for combining evidence to examine the support for a given hypothesis. WofE involves the estimation of a response variable (favourability for certain habitat occurrence) and a set of predictor variables (e.g. GIS layers containing environmental variables). WofE is based on a log-linear form of Bayes' rule and uses the prior probability distribution and the likelihood of the data to generate a posterior probability distribution.

Very few examples exist of WofE being used to predict the spatial distribution of species or communities using biophysical descriptors. This work explores WofE as a tool for rapid biodiversity assessment using georeferenced species information. Since the method is dependent of the indicator species used as a surrogate of biodiversity value it can be applied for assessing biodiversity conditions of both managed and protected areas to help decision-making concerning protection of valuable habitats. Thus, the map of habitat suitability, represented as a range of probabilities of occurrence, offers an objective framework for evaluating the outcomes of different scenarios. Similarly, an objective assessment of habitat suitability provides a rational basis for management decisions incorporating impact on species habitat.

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1. Introduction

In Europe, a wide variety of national and international legal mechanisms (e.g. EU-Habitats Directive (Directive 92/43/CEE) and EU-Bird Directive (Directive 79/409/CEE) and agri-environment measures of EU Common Agricultural Policy) have been established to protect the environment, ensure sustainable use of natural resources and maintain an acceptable level of biodiversity. Nonetheless, in order to achieve efficient monitoring systems that focus on the understanding of changes and its linkage to ecological processes, a thorough detailed-spatial knowledge of the landscape is vital (Spence, 2001). In this context, there is a need to develop indicators that simplify complexity in natural systems but still are well supported by high quality data. The problem in biodiversity monitoring and conservation is that usually exist vast gaps in available information on the spatial distribution of biodiversity that poses a major challenge for the development of biodiversity indicators and regional conservation planning. In order to improve ecological monitoring at the landscape level, it is possible to develop operational indicators from countries having detailed data on forest structure derived from National Forest Inventories (NFIs), not only to monitor forest conditions but also to assess the status of forest protection and valuable habitats (Luque et al., 2004a,b). It is becoming evident that new strategies of planning in the framework of sustainable development and within the framework of an integral/whole perspective are needed (Miller and Lanou, 1995; Soulé and Sanjayan, 1998; Gutzwiller, 2002). In this context, the habitat quality assessment and species distribution modelling could play an important role into regional planning. Within this rationality this work explores a rapid biodiversity assessment method using spatial analysis and existing datasets.

In the present work, we discuss a multicriteria approach by using a predictive habitat suitability model for three-toed woodpecker (*Picoides tridactylus*) based on Weights-of-Evidence (WofE) and a combination of remote sensing and field data derived from the Multisource Finnish National Forest Inventory (MS-NFI). WofE is an effective tool that combines spatial data to describe and analyse interactions and to provide support for decisions makers. The WofE model is a quantitative method used for combining evidence to examine the support for a given hypothesis. The model involves the estimation of a response variable (favourability for certain habitat occurrence) and a set of predictor variables (e.g. GIS layers containing environmental variables, thematic maps of forest type, soil properties, etc.). Most of the published applications of WofE are within the field of geology for mapping mineral potential due to its capability to combine patterns in maps in order to predict the probable distribution of point objects (Bonham-Carter, 1994; Bonham-Carter and Agterberg, 1999). Our aim is to test how appropriate WofE can be to create spatial habitat–species occurrence relationships.

Habitat quality assessment and habitat suitability maps can help to design management plans to expand protected areas or create new ones in order to protect certain species or habitats of particular importance in managed forest to improve regional planning (Romero-Calcerrada, 2002; Rautjärvi et al., 2004). Other than supporting program resource management, maps of habitat suitability, may as well find an application in evaluating a variety of land use change or other scenarios. For example, mapped habitat suitability allows the prediction of areas which may become occupied or unoccupied if the distribution of a species expands or contracts (Aspinall, 1992; Aspinall and Veitch, 1993). However, such changes will have biological or environmental causes and require additional information for accurate prediction. A map of habitat suitability, represented as a range of probabilities of occurrences, offers an objective framework for evaluating the outcomes of different scenarios (Aspinall, 1992). Similarly, an objective assessment of habitat suitability provides a rational basis for management decisions incorporating impacts on species habitat.

In Finland, a high proportion of commercial forests is within the sphere of woodlot-specific forest planning, which enables the use of a forest decision support system as a link between ecological knowledge and practical forestry (Store and Jokimaki, 2003; Nuutinen et al., 2001). In order to improve this existing forest management planning, it is essential that the decision alternatives be assessed with respect to a combination of expert knowledge and habitat models. A challenge is to develop methods and practices of locating and evaluating suitable sites for threatened species. The problem is that in the case of biodiversity conservation empirical evaluation models based on real field data for all species of interest cannot be expected to become available. One way of dealing with this problem, as proposed in this work, is to use indicator species and predictive models to identify possible causal relationships between species distribution, environmental data, and ecological conditions. The model proposed in this work is relatively easy to interpret and to use and constitutes an effective tool that combines spatial data to describe and analyse interactions while providing support for decisions makers.

2. Materials

2.1. *Lammi region as habitat for three-toed woodpeckers*

The structure of Fennoscandian boreal forest is relatively homogeneous due to the low tree species diversity (Essen et al., 1997). The study area – Lammi region – used in the present study is located in the south boreal zone according to the vegetation scheme developed by Ahti et al. (1968). The area selected within this region encompass 145,895 ha in Southern Finland (Fig. 1), dominated by coniferous forest, mostly Norway spruce. To the north the area remained wilderness-like because of stony and rough terrain, which is difficult to access and unfit for agriculture. More intensive use of the land can be seen towards a gradient to the south where agricultural land (14% of the total study area) dominates the landscape and clear cuts are more intense. To the north there are also several forest areas protected under different status including peatlands areas, which contrast with the more intensive land pressures to the south (Fig. 2). The landscape is dominated by forest land (71%) scattered with water bodies and lakes; urban areas are rather low (1.5%). Some of the freshwater habitats, within the area, are listed according to Annex 1 of