Focus

Evaluating and modelling the quality of forest habitats in Finland

**Similar to many other European countries, Finnish landscapes underwent profound change during the 1900s due to modifications in forest management.
The changes in landscapes produced the current situation in which a significant number of forest animal species are threatened.**

Forests with a rich lower stratum of herbaceous plants are among the most threatened habitats. These forests cover less than 2.4% of total forest land in the southern part of the country (Finnish Forest research institute, 2005). This is because no less than 50% of forests with a rich lower stratum of herbaceous plants were converted to agricultural land during the last century. In addition, the digging of ditches and the widespread use of spruce in the forestry industry caused further changes in vegetation. However, only 1.3% of forests with a rich lower stratum of herbaceous plants are protected in the southern part of the country (Finnish Forest research institute, 2005).

That is why the Finnish State is constantly looking for new, innovative methods for voluntary conservation of forests (Ministry of the environment, 2004). Currently, particular efforts are underway to protect forest biodiversity in the southern part of the country. But difficult choices must be made in determining what deserves priority attention because funding is limited. Before expanding protected zones or creating new ones, it is necessary to develop methods to locate and assess areas that would be favourable for the conservation of threatened species and, more generally, evaluate the quality and availability of habitats capable of receiving a sizable part of forest biodiversity on a regional or national scale.

Evaluating habitat quality for conservation purposes

To compensate the insufficiencies of empirical models for biodiversity evaluation, it is possible to develop habitat-quality models that provide information on the potential biodiversity of a given zone by identifying the cause and effect relations between forest structure and tree-species composition. The work relies and builds upon data from the Finnish National Forest Inventory (NFI, METLA) and other related databases from permanent inventories. Several conceptual approaches have been developed in order to evaluate different habitat-quality models that are used as a surrogate for biodiversity value.

We assume that all species have specific habitat requirements that may be described by the vegetation and soil characteristics, as well as by the spatial structure of the landscape. A first step in our work is to determine the ecological requirements of key species for the Finnish boreal forests on the basis of existing research and expert knowledge.

The goal is to produce different generalist regional models for forest-habitat quality and not to predict the habitat quality of a precise forest species. In this sense, landscape metrics and habitat modelling are used to understand patterns in the managed Finnish forests. The method helps to decide where to protect forest biodiversity based on the habitat value of the forest.

The final goal is to provide regional maps to assist in identifying a suitable set of additional protected zones while maintaining a balance between the financial investment (cost) and the expected conservation effects (benefit).

Defining the study zone and building the habitat-quality model

To provide answers on the regional level, the study was carried out on a total area of 16.7 million hectares of forest land in southern Finland (see figure ❶).

❶ **Study zone (in grey) in southern Finland, covering 16.7 million hectares of forest land.**

❶ Modelised forest-habitat, with a rich lower stratum of herbaceous plants.

The mapped habitats and variables used in the models were selected in compliance with the goals of the METSO 2003-2007 programme (see box ①).

Within this programme and at that time, we focussed on the rareness of protected forests with a rich lower stratum of herbaceous plants.

The thematic maps used for the models, at a resolution of 50 m. The pixel-level predictions were produced in the multi-source Finnish National Inventory (MS-NFI) (Tomppo *et al* 2008), i.e.:

- thematic maps on volumes of dead wood, growing stock volumes, stand ages and site productivity levels;
- estimates of the distribution of deadwood volumes, the surface areas of key biotopes and the density of zones where no forestry intervention has taken place for at least 30 years.

All data, including thematic maps were integrated to a common geographic-information system (GIS) database for the production of the habitat-quality models. Patch size and landscape characteristics provided important thresholds values for the resulting models.

The various layers were ranked as a function of specific thresholds based on the literature, expert knowledge, forest characteristics and an analysis of forest-characteristic landscape models (for more information, see Luque et Vainikainen, 2008).

Evaluating conservation goals using the habitat-quality model

A recent report by the Finnish Ministry of the environment recommended protecting forests with a rich lower stratum of herbaceous plants (see photo ❶) whatever their size and particularly if they are located in areas where their density is high. The model presented here is capable of identifying suitable zones for upcoming forest-habitat conservation projects.

The GIS platform used makes it possible to adjust and redefine the habitat-quality model for specific needs. The procedure and the models were used to determine conservation goals with two criteria in mind, i.e. biodiversity conservation and the economic value of forestry operations in zones with optimal habitats (Juutinen *et al.*, 2008; Kallio *et al.*, 2008).

The models can also assess the effectiveness of existing protected areas. The various types of protection were evaluated using the models. In particular, they were of use in detecting gaps in the protection of certain zones and in evaluating possibilities for expansion of the protection of existing areas in order to connect areas of small size.

① The METSO programme

The METSO programme for forest biodiversity in southern Finland was set up for the period 2003-2007 to fill out the 2010 national forest programme in terms of goals concerning sustainable social and economic aspects. New techniques based on voluntary efforts by forest owners were designed to ensure biodiversity preservation.

http://wwwb.mmm.fi/metso/ASIAKIRJAT/METSOn_jaljilla_ENG_Summary.pdf

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An example of an evaluation of existing protected areas is shown of figure ❷, in which we superposed the map of protected zones (outlined in red) with that of the herb-rich forest habitat quality values derived from the model (high index values shown in blue). It is clear from the model results that few "blue zones" are protected. It would appear necessary to expand conservation efforts to these non-protected zones or at least create corridors to establish sustainable connections between existing protected zones.

The maps derived from the modelling approach constitute useful means to rapidly assess candidate zones for biodiversity protection or protection extension. Using different buffer zones, the analysis identifies and estimates the degree of connectivity between protected zones and areas where there is a high probability of finding patches of herb-rich forest areas (see photo ❷), as well as patches of forest with good soil fertility (mineral composition). For example, a good candidate zone for protection was detected to the north of the study area and a new zone of value for conservation purposes and network protection was detected to the south (see figure ❸).

Value and limitations of the method, possible improvements

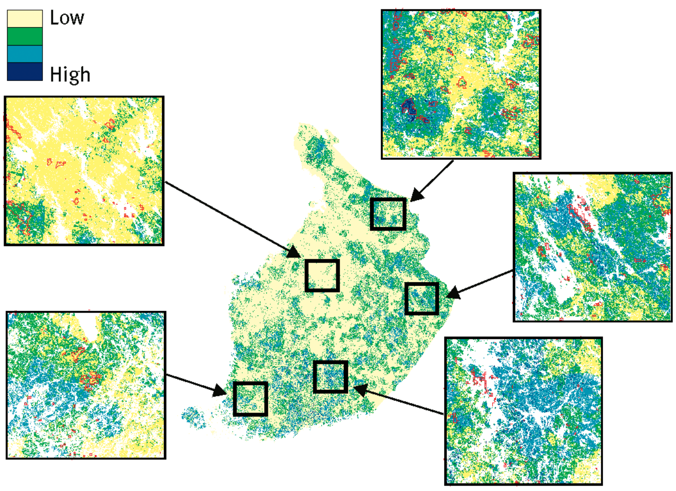
The method and the tools presented can be applied in assessing biodiversity value of both managed and protected forest areas to help decision-making concerning protection of valuable habitats and consequently manage natural resources. This effort constitutes the first attempt done on the landscape level, focusing on end users' needs, to use NFI data for biodiversity monitoring and management. The main purpose is to learn about habitat quality on a regional level for planning without the high costs and time required to collect quality census species data.

Many countries now have National Forest Inventories that are underused. Therefore, the idea is to use NFIs to plan for forest biodiversity protection in a sustainable manner. Furthermore, many countries have multisource inventories as presented here for the case of Finland (Tomppo *et al.*, 2008), using a combination of field measurements and satellite data. The accuracy of such data may in some cases be too coarse for small ecological-scale analysis, but nevertheless the inventories do provide repeated nationwide coverage of an array of forest measurements and the data can be analysed as presented here, using spatial statistics to produce information on landscape characteristics and to monitor forest quality. Data collection for forest inventories is constantly improving due to the use of Lidar and other laser-scanning techniques. The other advantage we showed, regarding the use of NFI data, is that instead of presenting a category of pine-dominated forest, for example, the proportion or volume of each tree species for each unit element, in our case a pixel, can be expressed precisely. Therefore, this information produced from NFI and field data allows regional planning with a certain precision depending on research objectives and/or users' needs.

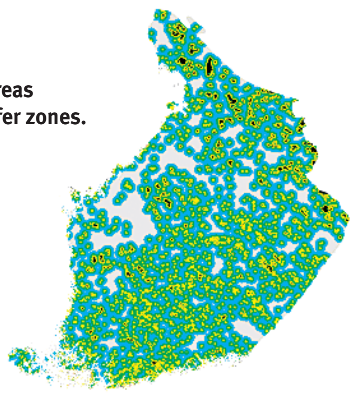
The habitat models can be improved with individual species data that will help to refine the thresholds. But the development of this type of habitat-quality model also helps to learn where to focus sampling efforts for particular species of local to regional importance. In this way, gradient analysis and a multiscale approach will be the next steps after the initial modelling phase presented here to improve sustainable forest management.

This approach can be enhanced considering the location of selected areas that may be targets for protection in the analysis. For this purpose, it would be important to identify which landscape elements are the most critical for the maintenance of overall forest landscape continuity and connectivity.

❷ The result layer of the herb-rich forest habitat quality model (high index values shown in blue) and superposed red zones showing existing protected areas to compare the distributions of the two types of zones.



❸ Distribution of protected areas and the corresponding buffer zones.



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Spatial configuration of protected stands may be an important issue in fragmented landscapes where individual dispersal among habitat patches is limited and a rule-of thumb recommendation is to spatially aggregate selected areas whenever possible. However, in boreal forest landscapes, where forest succession continuously alters stand and landscape characteristics, there is not much evidence that fragmentation affects species persistence. Therefore, habitat availability, not the spatial configuration, is the primary concern. It is possible to extend our approach to cover the spatial configuration of protected areas as well, but more sophisticated methods are needed to solve explicitly spatial site-selection problems.

However, our approach is simply a starting point for any planning projects given the limited precision of the remote-sensing data. Before going on to the operational phase of conservation, it is advised to carry out field assessments.

❷ Forest-habitat with a rich lower stratum of herbaceous plants (South of Finland).

Conclusion

The modelling technique presented here is based on the development of a flexible spatial GIS platform that can be used to handle large and complex databases. The approach constitutes a pragmatic and operational tool for decision-making regarding forest management strategies. The model makes possible rapid assessments in view of selecting suitable areas for protection while optimising costs (the financial investment) and benefits (conservation).

The approach has demonstrated its usefulness in developing operational methods for biodiversity monitoring (Luque et Vainikainen, 2006) and in helping to build a network of conservation areas for forest habitats that require protection. Other countries with a forest inventory would certainly benefit from developing similar methods. However, all protection projects must be backed up by a strategy combining protected areas and sustainable management of commercial forests. The method and the tools presented can be applied in assessing biodiversity value of both managed and protected forest areas to help decision-making concerning the protection of valuable habitats and consequently manage natural resources. ■

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▸ You can consult the bibliography on www.set-revue.fr