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An Introduction to New Landscape Ecology Research to Enhance Biodiversity in British Forests

INFORMATION NOTE

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SUMMARY

The importance of incorporating ecological knowledge in forest planning is stressed in *The UK forestry standard*, and by the UK Woodland Assurance Scheme (UKWAS). A landscape ecology research project has been set up by the Forestry Commission, as part of its Biodiversity Research Programme, to improve our understanding of ecological processes in woodland and forest landscapes in Britain. The research will initially test the approach in three study areas and in time provide tools and methodology to incorporate this into forest management through forest design planning.

INTRODUCTION

The need to manage on a wider scale

1. Sustainable forest management requires the maintenance of biodiversity, productivity, regeneration capacity, and forest health (Forestry Commission, 1998a). To achieve these objectives requires an understanding of ecological processes at the landscape scale.

2. Forestry practices modify habitat structure and composition, and such changes may have positive or negative impacts on biodiversity from the stand to the landscape scale. Effects at the stand scale are generally well understood, but landscape scale effects are harder to predict.

Ecosystem management

3. Ecosystem management requires an understanding of landscape ecology. This can be defined as the spatial arrangement of local ecosystems or land uses, and its effects on ecological processes.

4. Landscape ecology focuses on three characteristics of the landscape:

   - Structure - spatial relationships among the different elements present (e.g. distribution patterns in relation to sizes, shapes, numbers, types and configurations of landscape elements);
   - Function - interactions among the spatial elements (flows of energy, e.g. rivers and materials, and dispersal of species);
   - Change - alteration in structure and function of the landscape over time.

5. Analysis of the structure and function of forest patches within a landscape can aid our understanding of the ecological role and importance of those patches. Such knowledge can be used to evaluate potential changes to landscapes, whether they are due to natural processes or implemented as part of a design plan.

6. The spatial arrangement of forest mosaics determines the distribution and division of populations. The 'metapopulation concept' recognises that species can be divided into many short-lived sub-populations, whose genetic variation and dispersal abilities are altered as a result of changes in mosaic structure, thereby altering chances of population extinction or survival. Landscape scale data are likely to be the most common basis from which to predict population changes of flora and fauna in response to forest management.

7. For further information on landscape ecology, see Forman (1995), Hansson *et al.* (1995), DeGraaf and Miller (1996), Kohm and Franklin (1997), and Hunter (1999).

Application to British forests

8. Forest planning in Britain takes place at three levels: site level, forest level, and regional level. An appreciation of landscape ecology is relevant at each of these scales, and is important in meeting the criteria for sustainable forest management – e.g. maintenance of forest resources, health and vitality, productivity,

biodiversity, soil and water resources, socio-economic functions. *The UK forestry standard* (Forestry Commission, 1998a) provides the key framework for achieving sustainable forest management. Current forestry guidelines promote design principles that create a diverse age and physical structure, providing general guidance on suitable woodland sizes, incorporation of open space, creating networks to link both open space within woodlands, and also woodlands within the landscape.

9. Forest design planning allows examination of alternative forest management strategies, assessing their potential limitations and benefits. Largely aesthetic considerations have been replaced by a more holistic view of landscape scale forest planning (Forestry Commission, 1998b), taking into consideration opportunities for nature conservation and increasing biodiversity when planting and managing woodlands.

10. To comply with *The UK forestry standard*, or to receive certification under the UK Woodland Assurance Scheme (UKWAS Steering Group, 2000), long-term management plans are required. These should take account of environmental impacts; ecological enhancement; increasing diversity in habitats and ages; protection of rare species and habitats; the maintenance of biodiversity and ecological functions; and the conservation of semi-natural woodlands. It is important to consider the impacts of woodland/forest plans at a landscape level, taking due account of the interaction with adjoining land and other nearby habitats, e.g. avoiding fragmentation of important semi-natural habitats.

The need for research

11. Although we understand biodiversity at the stand scale increasingly well (Ferris *et al.*, 2000a; Ferris *et al.*, 2000b; Jukes *et al.*, 2000), and we know the broad influences of forest structure and composition; we cannot yet predict with precision the effects of alternative forest design and management systems on biodiversity conservation at the landscape scale. We also do not know the significance of various spatial configurations of woodlands in the wider landscape.

12. The Forestry Commission has therefore commissioned a landscape ecology research programme to address these gaps. We can only tackle part of such a large and complex subject, and will look to collaborate with partners for some aspects of landscape ecology research, especially to underpin the integrated planning of woodlands with other land uses in the wider landscape. There need to be linkages to research into other important ecological attributes as well as biodiversity, such as soil and water conservation.

PROPOSED FORESTRY COMMISSION RESEARCH PROGRAMME

13. The overall objective of this project is to improve our understanding of how biodiversity responds to management at the landscape scale, and to translate this into practical management guidance. This knowledge can then be combined in forest planning with other predictions of the effects of plans on economic, social and aesthetic values.

Specific objectives

14. After review of UK practice and of the approaches adopted elsewhere, the following objectives are proposed:

- Determine the feasibility of using landscape indices as a method for characterising spatial pattern and process in British forests.
- Investigate the impact of current and alternative management systems, including those based on natural disturbance regimes, on the spatial pattern of landscape elements, and on potential biodiversity in the future.
- Test the value of particular landscape patterns and dynamics for maintaining and enhancing populations of a range of species groups with differing habitat requirements and dispersal abilities.
- Provide systems for guiding forest managers in decision making to conserve or enhance selected species groups, allowing evaluation of the effects of different management operations.

Approach

Landscape indices

15. A suite of landscape indices will be identified which have previously been used in analysis and description of spatial pattern and process in forested landscapes, e.g.:

- Patch size
- Edge to area ratio
- Core area
- Patch shape
- Inter-patch distance
- Connectivity

The indices will then be tested for their suitability for spatial characterisation, using data from three case study areas (see below). Those indices able to distinguish reliably between spatial characteristics known to have an impact on distribution patterns and movement of plant and animal species (particularly those for which Species Action Plans exist, or those with important functional roles in the ecosystem), will be studied further.

Landscape standards

16. Information will be collated on recommendations and standards for forest operations in relation to conservation of biodiversity and ecosystem protection. This will draw on the *Forest nature conservation guidelines* (Forestry Commission, 1990), *Forests & water guidelines* (Forestry Commission, 1993), *Forests and soil conservation guidelines* (Forestry Commission, 1998c), Forestry Practice Guides 1-8 on *The management of semi-natural woodlands* (Forestry Commission, 1995), *The UK forestry standard* (Forestry Commission, 1998a), and the UKWAS criteria (UKWAS Steering Group, 2000). These 'rules' will then be used as constraints and opportunities in analysis of forest design plans for the study sites and elsewhere, using geographical information systems (GIS). This will permit testing of compliance with these standards, and highlight areas of conflict with other management objectives; as well as allowing alternative scenarios to be developed and appraised.

Spatial use by organisms

17. Species or groups will be selected on many criteria, such as current knowledge, conservation status (e.g. Biodiversity Action Plan species), their role in ecosystem functioning, and whether they are feature or flagship species for the local area or region. An expert panel will be convened in October 2000, to inform the selection process. Detailed forest-scale studies at a limited number of study sites will address the implications of the existing spatial pattern on selected species/species groups; and use scenario modelling to assess the likely impact of future landscape patterns resulting from design planning. This will involve field assessments of habitat use by the selected species, to establish distribution patterns and identify key features either encouraging or limiting dispersal.

Decision Support System construction

18. The landscape indices and appreciation of their usage will feed into the development of spatial rules for managers, as the final phase of this project, for completion by April 2003. These will integrate with the developing Decision Support System, currently based upon Ecological Site Classification (Pyatt and Suárez, 1997) as the core module, for completion by April 2004.

19. The project is expected to deliver a number of publications, both in the scientific literature and as practical publications for use in forest management. It is anticipated that information and practical guidance will also be available through training courses and provision of advice.

INITIAL STUDY AREAS

20. Three initial study areas have been chosen for testing the relevance of landscape indices for woodland and forest landscapes in the UK. Sites in the areas of Sherwood, Glen Affric and Clocaenog have been chosen to provide a range of different forest types and complexities.

Sherwood

21. The Sherwood study area is based around Clipstone Forest, in the English Midlands. This area is fairly typical of lowland forest landscapes in southern Britain. The landscape has been heavily altered by humans, with many population centres and an industrial mining heritage. Despite there being little natural variation, either in climate, elevation or soils, the landscape is complex, with a mixture of woodland patches largely surrounded by arable land. Research has examined changes in the extent and spatial pattern of semi-natural woodland and heathland, quantifying these using a number of landscape indices (Ferris and Purdy, in preparation). Ancient semi-natural woodland cover has been greatly reduced over the past 200–300 years, and hedgerow removal has led to a high degree of fragmentation. Much of the present woodland cover comprises plantations, often of non-native

conifers. English Nature is using the Sherwood Natural Area as a study site for its habitat restoration project, and this will allow co-operation with data and site information, and species habitat modelling. Of particular ecological importance in the region are deadwood invertebrates, associated with veteran oaks scattered through the landscape and within ancient semi-natural woodland fragments. Socio-economic research is being carried out by Nottingham University, evaluating different restoration strategies with reference to cultural perceptions and expectations of the local population.

Figure 1 Locations of the three study areas

Glen Affric

22. The Glen Affric study site, in the Highland region of Scotland, contains greater topographic variation, giving rapid changes in climate and soil type, providing a distinct contrast to the Sherwood landscape. The landscape is characterised by a mosaic of wooded and non-wooded vegetation (mostly wet heath and mire communities), covering three main elevational zones: the Alpine, Sub-Alpine and Forest zones. Over the past 200–300 years, native woodland cover (Scots pine and birch) within the Forest zone has been much reduced through burning, over grazing and tree-felling. However, in recent years a reduction in grazing pressure has allowed a proportion of the stands to regenerate naturally, and the native woodland area is increasing. Management is concentrating on expanding the area of Caledonian pinewoods. Initial research has focused on modelling the potential expansion of native woodland on to currently open habitats and evaluating the impact of natural disturbance (wind) on the structure and dynamics of the wooded areas (Humphrey, in preparation). This work is being taken forward through a Ph.D. project based at Stirling University, the aim of which is to develop a GIS-based spatially-explicit model of native woodland expansion and dynamics. In the future this model will be developed into decision support software to help managers decide how to manage a changing forest landscape to benefit key species such as capercaillie.

Clocaenog

23. The Clocaenog study area in North Wales is a landscape intermediate between Sherwood and Glen Affric, both in scale and complexity. The forest landscape of Clocaenog is dominated by a managed plantation dating from the early 1900s. The stands contain a range of species, but are dominated by conifers, mainly Sitka Spruce, with some Norway Spruce and some Scots pine (mixed in with stands of spruce). There are small patches with variation in age and species characteristics, but much larger blocks of adjacent sub-compartments that are similar in age and species (planted in the 1950s and 60s). There are few patches of broadleaved woodland, and these are spread thinly across the forest, with a small concentration of beech stands in the east. Recent broadleaved planting has tended towards small patches of mixed species. Clocaenog is an important area for red squirrel conservation, and this has been subject of related studies by Queen Mary and Westfield College, London.

Further studies

24. Other study areas will be selected to test and refine the sub-set of landscape indices produced from the first analysis. The spatial and temporal patterns of these sites will be analysed and compared using the selected indices. Their ability to differentiate between pairs of contrasting and pairs of similar forest types will be further evaluated.

25. In order that a range of site types and climatic conditions are covered, in addition to a range of crop types and management regimes, sites will be selected using Ecological Site Classification (ESC; Pyatt and Suárez, 1997) and the National Vegetation Classification (NVC; Rodwell, 1991).

CONCLUSIONS

26. This project represents exciting new, multidisciplinary research, forming a natural progression from existing work on biodiversity assessment at the stand scale. It is closely linked to research programmes on Species Action Plans, Habitat Management, and Decision Support Systems. As such it demands partnerships between researchers, policy-makers and managers. The fieldwork will be managed by Woodland Ecology Branch of Forest Research, but will be undertaken by a range of organisations. Comments on this project are welcomed, and further information can be obtained from Richard Ferris at the address on the back page of this Note.

REFERENCES AND FURTHER READING

DEGRAAF, R. M. AND MILLER, R. I. (eds) (1996).
Conservation of faunal diversity in forested landscapes.
Chapman and Hall, London.

DIAZ, N. AND APOSTOL, D. (1992).
Forest landscape analysis and design: a process for developing and implementing land management objectives for landscape patterns.
USDA Forest Service, Pacific Northwest Region.

FERRIS, R., PEACE, A. J., HUMPHREY, J. W. AND BROOME, A. C. (2000a).
Relationships between ground vegetation, site type and stand structure in coniferous plantations in Britain.
Forest Ecology and Management, (in press).

FERRIS, R., PEACE, A. J. AND NEWTON, A. C. (2000).
Macrofungal communities of lowland Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karsten.) plantations in England: relationships with site factors and stand structure.
Forest Ecology and Management, (in press).

FERRIS, R. AND PURDY, K. M. (in preparation).
A landscape-scale approach to forest design and biodiversity conservation in the Sherwood Natural Area.
In: *The potential application of landscape ecology in forest design planning*.
Forestry Commission Technical Paper.
Forestry Commission, Edinburgh.

FORESTRY COMMISSION (1990).
Forest nature conservation guidelines.
HMSO, London.

FORESTRY COMMISSION (1993).
Forests & water guidelines.
HMSO, London.

FORESTRY COMMISSION. (1995).
The management of semi-natural woodlands.
Forestry Practice Guides 1-8.
Forestry Commission, Edinburgh.

FORESTRY COMMISSION (1998a).
The UK forestry standard:
The Government's approach to sustainable forestry.
Forestry Commission, Edinburgh.

FORESTRY COMMISSION (1998b).
Forest design planning: a guide to good practice.
Practice Guide.
Forestry Commission, Edinburgh.

FORESTRY COMMISSION (1998c).
Forests and soil conservation guidelines.
Forestry Commission, Edinburgh.

FORMAN, R. T. T. (1995).
Land mosaics: the ecology of landscapes and regions.
Cambridge University Press, Cambridge.

HANSSON, L., FAHRIG, L. AND MERRIAM, G. (eds) (1995).
Mosaic landscapes and ecological processes.
IALE Studies in Landscape Ecology 2.
Chapman and Hall, London.

HUMPHREY, J. W. (in preparation).
Modelling vegetation succession in Glen Affric: implications for biodiversity and tree regeneration in a forest landscape. In: *The potential application of landscape ecology in forest design planning*.
Forestry Commission Technical Paper.
Forestry Commission, Edinburgh.

HUNTER, M. L. Jr. (ed.) (1999).
Maintaining biodiversity in forest ecosystems.
Cambridge University Press.

JUKES, M. R., PEACE, A. J. AND FERRIS, R. (2000).
Carabid beetle communities associated with coniferous plantations in Britain: the influence of site type, ground vegetation and stand structure.
Forest Ecology and Management, (in press).

KOHM, K. A. AND FRANKLIN, J. F. (eds) (1997).
Creating a forestry for the 21st Century: the science of ecosystem management.
Island Press, Washington D.C.

McGARIGAL, K. AND MARKS, B. (1995).
FRAGSTATS: spatial analysis program for quantifying landscape structure.
USDA Forest Service General Technical Report PNW-GTR-351.

PYATT, D. G. AND SUÁREZ, J. C. (1997).
An ecological site classification for forestry in Great Britain; with special reference to Grampian, Scotland.
Forestry Commission Technical Paper 20.
Forestry Commission, Edinburgh.

PYATT, D. G., RAY, D. AND FLETCHER, J.
(in preparation).
An ecological site classification for forestry in Great Britain.
Forestry Commission Technical Paper.
Forestry Commission, Edinburgh.

RODWELL, J. S. (1991).
British plant communities, Vol. 1: *Woodlands and scrub*.
Cambridge University Press, Cambridge.

UKWAS STEERING GROUP (2000).
Certification standard for the UK Woodland Assurance Scheme.
UKWAS Support Unit,
Forestry Commission, Edinburgh.

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