Forestry Commission
231 Corstorphine Road
Edinburgh
EH12 7AT
www.forestry.gov.uk

Evaluating Biodiversity in Fragmented Landscapes: The Use of Focal Species

INFORMATION NOTE

BY A. EYCOTT, K. WATTS, D. MOSELEY AND D. RAY OF FOREST RESEARCH

OCTOBER 2007

SUMMARY

Landscape ecology allows evaluation of the impacts of landscape change upon biodiversity, enabling more effective planning and management of landscapes. In *Evaluating biodiversity in fragmented landscapes: principles*, Watts *et al.* (2005b) describe the scientific principles behind Geographical Information System (GIS) tools for addressing habitat fragmentation, and *Evaluating biodiversity in fragmented landscapes: applications of landscape ecology tools* (Watts *et al.*, 2007) gave examples of how these tools are applied to target biodiversity conservation action and evaluate landscape change. This Information Note describes in more detail how profiles for species, both real and 'generic', are used in such tools. Terminology describing the use of different species in ecological studies and landscape modelling is also defined.

INTRODUCTION

The loss and fragmentation of woodland habitat into smaller, more isolated patches poses one of the key threats to forest biodiversity, alongside habitat degradation. Habitat fragmentation changes woodland pattern and distribution in the landscape and, in turn, species may respond in quite different ways depending on their particular characteristics, such as breeding habitat requirements, foraging patterns and mobility. A species-based approach is therefore necessary to interpret the impacts of fragmentation on biodiversity.

HOW DOES FRAGMENTATION IMPACT ON SPECIES?

Habitat fragmentation impacts on species in two main ways: by reducing patch area and by increasing patch isolation.

Reduced patch area

Smaller woodlands tend to have fewer woodland specialist species. It is unclear whether this is due to the direct effect of habitat area on population size, or because smaller woodlands contain less microhabitat diversity or are more influenced by edge effects, such as increased light, pesticide drift or human disturbance. It is likely to be a combination of these factors, with the species richness of less mobile species (e.g. clonally reproducing plants, Peterken and Game, 1984) more influenced by microhabitat diversity, and the number of more mobile species (e.g. birds, Bellamy *et al.*, 1996) directly affected by habitat area.

Increased patch isolation

As habitat patches become more isolated, an important aspect of a species' response is its ability to move between patches, i.e. its dispersal ability. Some species (e.g. large birds) will move between patches regardless of the landscape features encountered and in such cases the extent of movement between patches may be related to geographical distance alone. Other species will be more affected by landscape features encountered between patches, in which case the composition of the land must be considered when assessing fragmentation. Different land-use types will have differing effects on a species' ability to move; some will allow individuals to move freely, others will restrict them or act as a complete barrier (Figure 1). For many woodland species, semi-natural and extensive habitats such as scrub or heath are considered to be more conducive, or permeable, to species movement, while intensive land uses such as arable fields and urban areas are regarded as less permeable, thereby reducing inter-patch movement and effectively increasing ecological isolation.

FRAGMENTATION AND SPECIES CONSERVATION

Fragmentation can have some positive impacts. It is likely that a degree of isolation is natural, and indeed helpful – events such as a disease or predator outbreak would then be less likely to affect all patches. However, it is becoming increasingly clear that many species cannot be protected by conserving completely isolated populations in patches

Figure 1

Land use between habitat patches may have an effect on species movement, for example a deer reaching a road may (a) decide to cross it, risking mortality, or (b) avoid it and remain in more suitable habitat, isolated from other deer populations.

Rupert Randall

of protected habitat within hostile landscapes. If such isolated populations were eventually lost there would be little chance of the patches being recolonised.

Species that have fairly large habitat area requirements and relatively short dispersal distances are likely to be impacted by fragmentation (Table 1). Species that have very poor dispersal are unlikely to move beyond the boundary of their individual habitat patch and so their response to fragmentation is based only upon habitat area.

USING SPECIES TO ANALYSE FRAGMENTATION

Modelling studies help to make order of the complexity inherent in working with highly modified landscapes such as those found in the UK. However, the range of terms used to describe species in fragmentation studies is varied and subject to debate (Caro, 2000). Table 2 describes and clarifies the terms associated with species research and modelling. Of these terms, 'target species' and 'focal species' are the most frequently used in landscape ecology research carried out by the Forestry Commission.

Target species

Target species are those that are the specific 'target' of research and action, for example the UK plan for bitterns is to achieve 50 booming males by 2010. Work to support target species is not directly intended to help other species.

Table 1

Species affected by fragmentation are likely to be those that require a large habitat area and have short dispersal distances. Species that do not disperse at all are unlikely to be helped by improving connectivity. Table sourced from Watts *et al.*, 2005b.

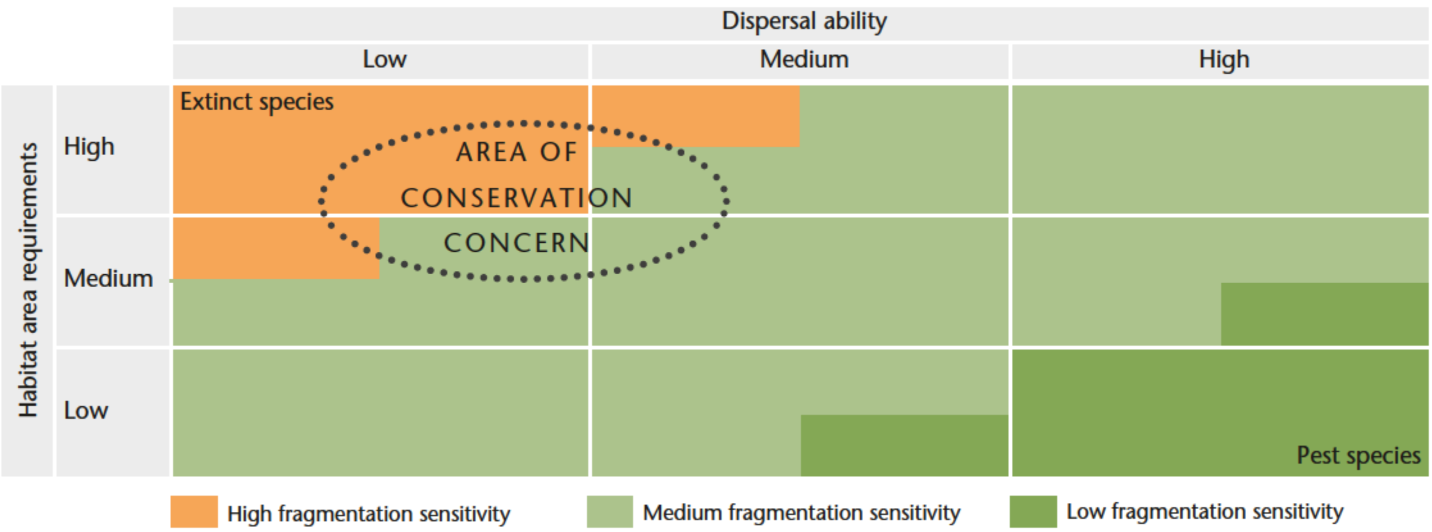


Table 2

Species terminology: a guide to different categorisations of species used in, or the focus of, landscape ecology research, plus other categories used in broader ecological research. Note that this table does not include terms for the conservation or legal protection status of species. For information on these designations see: www.forestresearch.gov.uk/harpps

	Definition	Example
Target species	General: the specific 'target' of research and action. Within FC: Species on the list for each devolved country as being the focus of research and conservation action.	Bitterns, red squirrels. Capercaillie, scarce lime bark beetle, twinflower.
Focal species	General: the species of interest or study. Lambeck (1997): a profile that covers the needs of all the threatened species present in a landscape.	
Keystone species	Species that have an effect on ecosystem function which is disproportionately large compared to their biomass/number.	Cassowary, deer in temperate Europe (Bruinderink, 2003).
Indicator species	A species used to monitor environmental change or condition.	Ancient woodland indicator species (Rose, 1999).
Umbrella species	A species that is used to represent *some* of the needs of some other species.	Grizzly bear (Carrol *et al.*, 2001).
Surrogate species	A species used to look for effects of change in another, rarer species or one that is more difficult to record (sometimes also called an indicator species).	Barn owl (pellets used to record vole populations).
Substitute species	Either a surrogate species or one that is used when the species of interest is not suitable for research due to conservation or ethical reasons.	Laboratory animals, e.g. mice, as substitutes for humans in biomedical research.
Flagship species	Species that, by being charismatic or famous, can attract funding which will help other species at the same time.	Giant pandas, bitterns, ospreys (category dominated by mammals and birds).

There is a wide range of important species within Britain's forests and associated open spaces and watercourses. Each of the Forestry Commission National Offices has a list of target species that they have a duty of care to protect, conserve and enhance while managing forests. Some of these species are currently the subjects of research by the Forestry Commission and Forest Research (Broome *et al.*, 2005).

Focal species

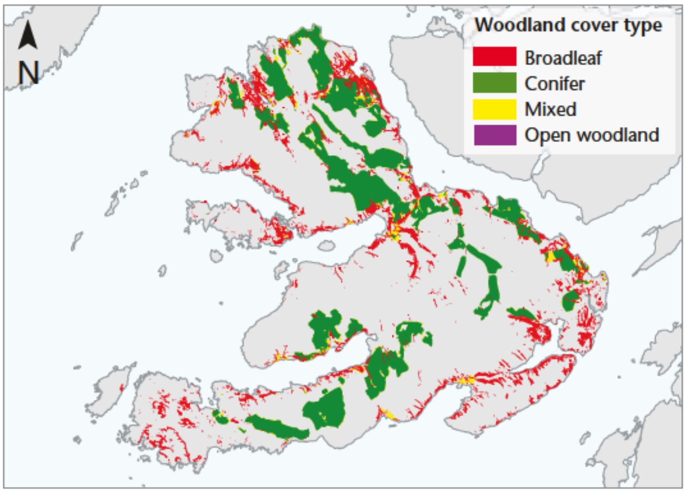
Focal species in the landscape ecology literature can mean one of two things. The first, more general definition is simply 'the species being focused on to examine a particular issue'. Such focal species can be used to model either the structural connectedness or functional connectivity of a landscape. A focal species might be chosen for various reasons, e.g. it is of conservation concern, has good availability of data, or has a restricted geographic range despite widely available habitat. Modelling approaches based on this type of focal species require characterisation of their sensitivity to fragmentation by construction of species profiles. For example, a study on the island of Mull used four focal species to predict habitat availability and connectivity under future land-use scenarios, in order to represent groups of species associated with certain habitats on the island (Humphrey *et al.*, 2005). The song thrush (*Turdus philomelos*) was used to represent species that use open ground and woodland mosaics (Figure 2) and the lichen *Pseudocyphellaria norvegica* was used to represent ancient woodland specialist species with exacting habitat requirements. The marsh fritillary (*Eurodryas aurinia*) was used to represent species associated with wet grassland habitat and the slender Scotch burnet (*Zygaena loti*) represented early-successional cliff-grassland species. In another study in northeast Wales, great crested newts were the focal species used for functional habitat network modelling as they are a Forestry Commission Wales target species whose decline has been linked to habitat fragmentation. The 'focal species profiles' (i.e. home habitat patch requirement, maximum dispersal distance and land-use permeability scores) for song thrush, lichen and great crested newts are given in Table 3.

The second meaning of 'focal species' is derived from a method where landscapes are evaluated according to the most rigorous requirements of all the species present (Lambeck, 1997). The species present are divided into two: those with declining populations and those that are stable or increasing. The declining species are then divided into four groups according to the cause of their decline: habitat management, habitat area (including patch size), resource availability, or limited dispersal capability. From each of the four groups, the species with the strictest requirements is then used to help form a single management plan based around the four causes of decline.

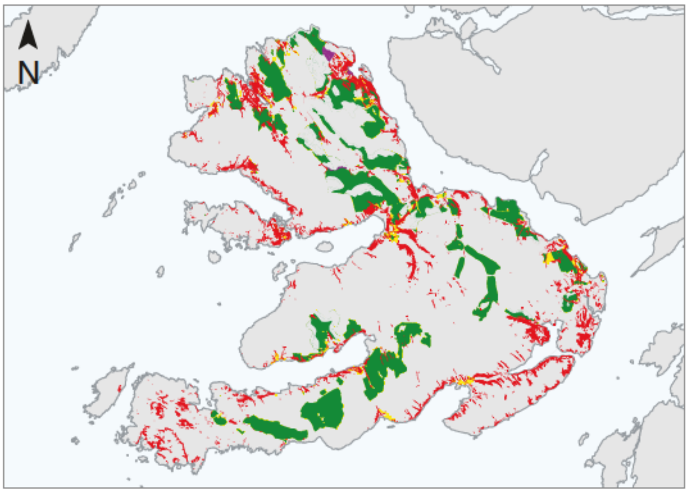
Figure 2

Woodland distribution on the island of Mull and the corresponding song thrush habitat networks. As open ground increases, song thrush habitat networks decline in mean area (from 198–180 ha) and rise in number (from 238–254) as they become more fragmented.

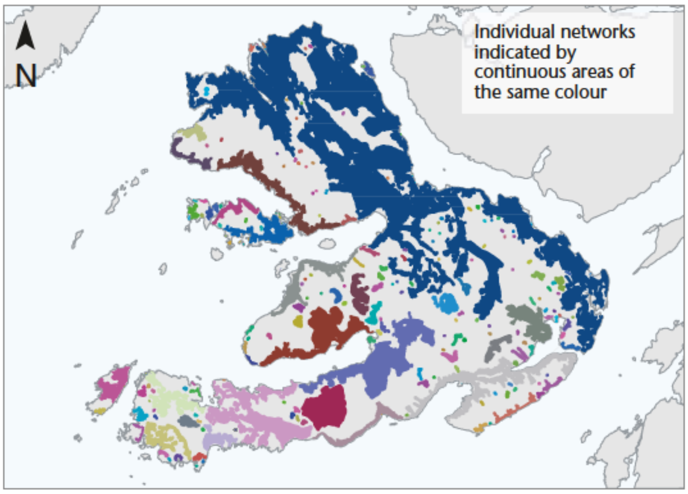
a) Current woodland distribution.



b) A possible future woodland distribution.



c) Current song thrush habitat networks.



d) Habitat networks for the possible future woodland distribution in b).

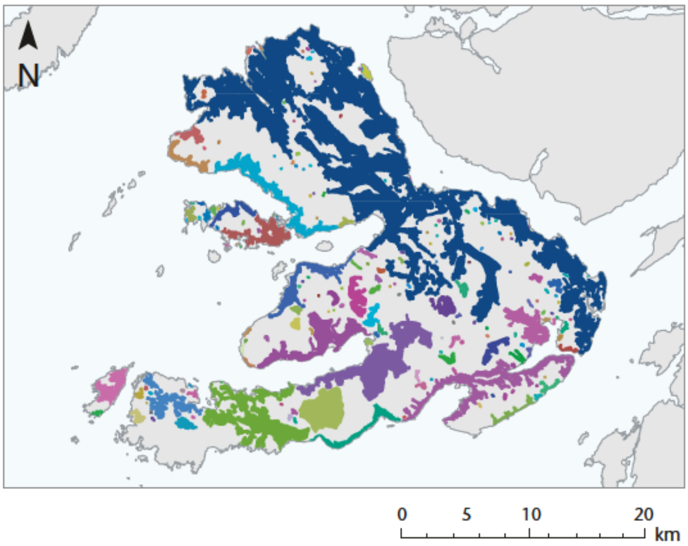


Table 3

Focal species profiles for the song thrush and lichen *Pseudocyphellaria norvegica* on Mull (Humphrey *et al.*, 2005), great crested newts in northeast Wales and a generic focal species (broadleaved woodland species) in Wales (Watts *et al.*, 2005a).

Focal species	Maximum dispersal distance	Habitat type	Patch size	Relative resistance of species to cross certain land cover types between patches	
				Land cover type	Relative resistance*
Song thrush	5 km	Woodland, scrub and grazed permanent pasture	Not specified	Woodland, scrub, improved grassland	1
				Bracken	10
				Wet habitats, swamp	20
				Urban, roads, open water	50
Lichen *Pseudocyphellaria norvegica*	50 m	Humid and sheltered ancient hazel, oak and mixed broadleaved woodland (NVC categories W9, W11)	Not specified	Ash/oak woodland (W9, W11)	1
				Other semi-natural broadleaved woodland	2
				Modified woodland	10
				Other non-woodland habitats	20
				Urban, roads, open water	50
Great crested newt	1 km	Standing fresh water	10 m^2–750 m^2	Open grassland (improved and unimproved), arable	1
				Rough grassland, broadleaved woodland and mosaic habitats	2
				Dry heathland, fen and scrub	5
				Wet heathland, mire and mud	10
				Running water, urban, roads	200
Broadleaved woodland generic focal species	1 km	Broadleaved woodland	10 ha	Broadleaved/mixed woodland, dense scrub, bracken, willow fen, dune scrub	1
				Marshy grassland, heath and mire	3
				Unimproved grassland, scree slopes	5
				Conifer plantation, semi-improved grassland, bog, swamp, gardens	10
				Improved grassland, salt marsh, dunes, arable, rock, amenity grass	20
				Open water, urban, roads, buildings	50

*1 = no resistance

Although this approach is conceptually attractive, it is extremely difficult to implement because of the lack of the required information. Identifying all declining species is difficult as most areas do not have comprehensive species lists, especially for invertebrates and micro-organisms. The approach is further hindered by insufficient landscape composition data to assess habitat availability. However, it is still useful to consider species in groups according to their causes of decline. In fragmentation studies, the concern is primarily with those species affected by isolation (i.e. limited dispersal) and those affected by habitat area. As a result, Forest Research has developed the generic focal species approach.

GENERIC FOCAL SPECIES PROFILES

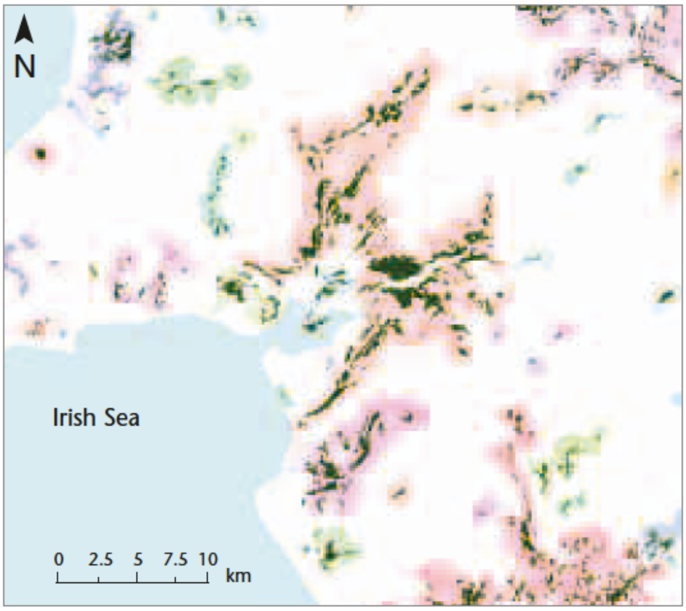
A generic focal species is a conceptual species, whose profile consists of a set of ecological requirements reflecting the likely needs of real species where species data are unavailable. A set of generic focal species should encompass the needs of most (but not all) real species that need to be considered in the landscape plan or evaluation. This is similar to using an umbrella species (Table 2) except that the profile is not based on one actual species, but on a combination of most species' needs. The profiles are developed in consultation with species and habitat specialists.

In examining woodland habitat fragmentation, generic focal species need to be defined by habitat requirement and dispersal ability. These values are set to be at least as demanding as the values (measured or assumed) of the majority of the species that may be expected in that woodland habitat. The habitat networks method described by Watts *et al.* (2005a) includes the habitat type, minimum patch size, maximum dispersal distance and response to various land uses as parameters. An example of a generic focal species profile for a Welsh broadleaved woodland species is given in Table 3, and the corresponding habitat network map generated is shown in Figure 3.

Generic focal species are an integral part of the Biological and Environmental Evaluation Tools for Landscape Ecology (BEETLE) suite of tools (Watts *et al.*, 2005b) and various research projects in Forest Research (Watts *et al.*, 2007). Other landscape ecology models follow a similar approach. For example, work by Alterra in the Netherlands uses 'eco-profiles' (Opdam *et al.*, 2003) for the LARCH model, which evaluates the potential of landscapes to support biodiversity conservation.

Figure 3

Habitat networks map around Porthmadog in northwest Wales generated by the generic focal species profile for a broadleaved woodland species as shown in Table 3. Networks are in various colours and broadleaved woodland dark green. These maps are being used by the Meirionnydd Oakwood Habitat Management Project and Forestry Commission Wales to actively combat native woodland fragmentation in Wales. Figure sourced from Watts *et al.* (2005b).



CONCLUSIONS AND FUTURE RESEARCH

Focal species, both 'real' and 'generic', offer a practical tool for forest planners and managers, enabling work to be progressed from focusing only on set 'target species' and to create woodlands that benefit a range of biodiversity. This means that the impacts on biodiversity of future forest patterns and wider land-use change can be evaluated alongside other needs and objectives, for example timber production and recreation.

Generic focal species profiles have proved useful given the lack of species-based evidence on the impact of fragmentation on biodiversity, and the pressing need to generalise and develop evaluation tools. The approach incorporates the best aspects of the Lambeck method, but deals pragmatically with its problems. While the generic focal species method is not the most thorough and robust system possible, it is effective and immediately available. As Hobbs (1997, p.2) states: 'if our science cannot be applied to real world problems, we must question why we are doing it in the first place'.

However, there is now a growing need to refine and validate the parameters used within the generic profiles to increase the robustness of this approach and subsequent applications. As more information becomes available, it will be very useful to group 'real' species within these broader generic profiles. Establishing where real species fit into Table 1 should allow us to predict how they are likely to be affected by fragmentation in any given landscape. This should also enable us to validate our generic species profiles by testing whether real species with similar characteristics are distributed in line with modelled predictions.

At present, the generic focal species approach is used to study connectivity for species of conservation concern that are negatively affected by habitat fragmentation, but in the future it could be developed to assess invasive species or those species of conservation concern that are affected by fragmentation in a more complex manner. In addition, we are combining outputs from the decision-support tool Ecological Site Classification (ESC) (Pyatt *et al.*, 2001), climate models and BEETLE in order to examine the possible impact of climate change in exacerbating the effects of habitat fragmentation.

REFERENCES

BELLAMY, P.E., HINSLEY, S.A. and NEWTON, I. (1996). Factors influencing bird species numbers in small woods in south-east England. *Journal of Applied Ecology* 33 (2), 249–62.

BROOME, A., QUINE, C., TROUT, R., POULSOM E. and MAYLE, B. (2005).
The link between forest management and the needs of priority species: research in support of the UK Biodiversity Action Plan. *Forest Research Annual Report and Accounts 2003–2004.*

BRUINDERINK, G.G., VAN DER SLUIS, T., LAMMERTSMA, D., OPDAM, P. and POUWELS, R. (2003).
Designing a coherent ecological network for large mammals in northwestern Europe. *Conservation Biology* 17 (2), 549–57.

CARO, T. (2000).
Focal species. *Conservation Biology* 14 (6), 1569–70.

CARROLL, C., NOSS, R.F. and PAQUET, P.C. (2001). Carnivores as focal species for conservation planning in the Rocky Mountain region. *Ecological Applications* 11 (4), 961–80.

HOBBS, R. (1997).
Future landscapes and the future of landscape ecology. *Landscape and Urban Planning* 37, 1–9.

HUMPHREY, J.W., BROWN, T., RAY, D., GRIFFITHS, M., WATTS, K. and ANDERSON, A.R. (2005).
Balancing upland and woodland strategic priorities. Phase 3: testing an approach to landscape evaluation for biodiversity on the Isle of Mull based on focal species modelling. Contract report to Forestry Commission Scotland and Scottish Natural Heritage.

LAMBECK, R.J. (1997).
Focal species: A multi-species umbrella for nature conservation. *Conservation Biology* 11 (4), 849–56.

OPDAM, P., VERBOOM, J. and POUWELS, R. (2003). Landscape cohesion: an index for the conservation potential of landscapes for biodiversity. *Landscape Ecology* 18 (2), 113–26.

PETERKEN, G.F. and GAME, M. (1984).
Historical factors affecting the number and distribution of vascular plant species in the woodlands of central Lincolnshire. *Journal of Ecology* 72, 155–82.

PYATT, D.G., RAY, D. and FLETCHER, J. (2001). *An Ecological Site Classification for Forestry in Great Britain*. Forestry Commission Bulletin 124. Forestry Commission, Edinburgh.

ROSE, F. (1999).
Indicators of ancient woodland: the use of vascular plants in evaluating ancient woods for nature conservation. *British Wildlife* 10, 241–51.

WATTS, K., GRIFFITHS, M., QUINE, C., RAY, D. and HUMPHREY, J.W. (2005a).
Towards a woodland habitat network for Wales. Contract Science Report No. 686, Countryside Council for Wales, Bangor.

WATTS, K., HUMPHREY, J.W., GRIFFITHS, M., QUINE, C. and RAY, D. (2005b).
Evaluating biodiversity in fragmented landscapes: principles. Forestry Commission Information Note 73.
Forestry Commission, Edinburgh.

WATTS, K., RAY, D., QUINE, C.P., HUMPHREY, J.W. and GRIFFITHS, M. (2007).
Evaluating biodiversity in fragmented landscapes: applications of landscape ecology tools.
Forestry Commission Information Note 85.
Forestry Commission, Edinburgh.

This Information Note is one of three on biodiversity evaluation in fragmented landscapes:

- FC Information Note 73, *Evaluating biodiversity in fragmented landscapes: principles*
- FC Information Note 85, *Evaluating biodiversity in fragmented landscapes: applications of landscape ecology tools*

Further information is also available at www.forestry.gov.uk/landscapeecology

Enquiries relating to this publication should be addressed to:

Dr Amy Eycott
Ecology Division
Forest Research
Alice Holt Lodge
Farnham, Surrey
GU10 4LH

T: 01420 526200
F: 01420 520180
E: amy.eycott@forestry.gsi.gov.uk

www.forestresearch.gov.uk/landscapeecology

ISSN 1460-3802
ISBN 978-0-85538-738-9

FCIN089/FC-GB(ED)/ALDR-1.5K/OCT07