Final Report 29 March 2004

DEVELOPMENT OF A FOREST HABITAT NETWORK STRATEGY IN WEST LOTHIAN

Contract No AB(LJ15)0304118 to Scottish Natural Heritage

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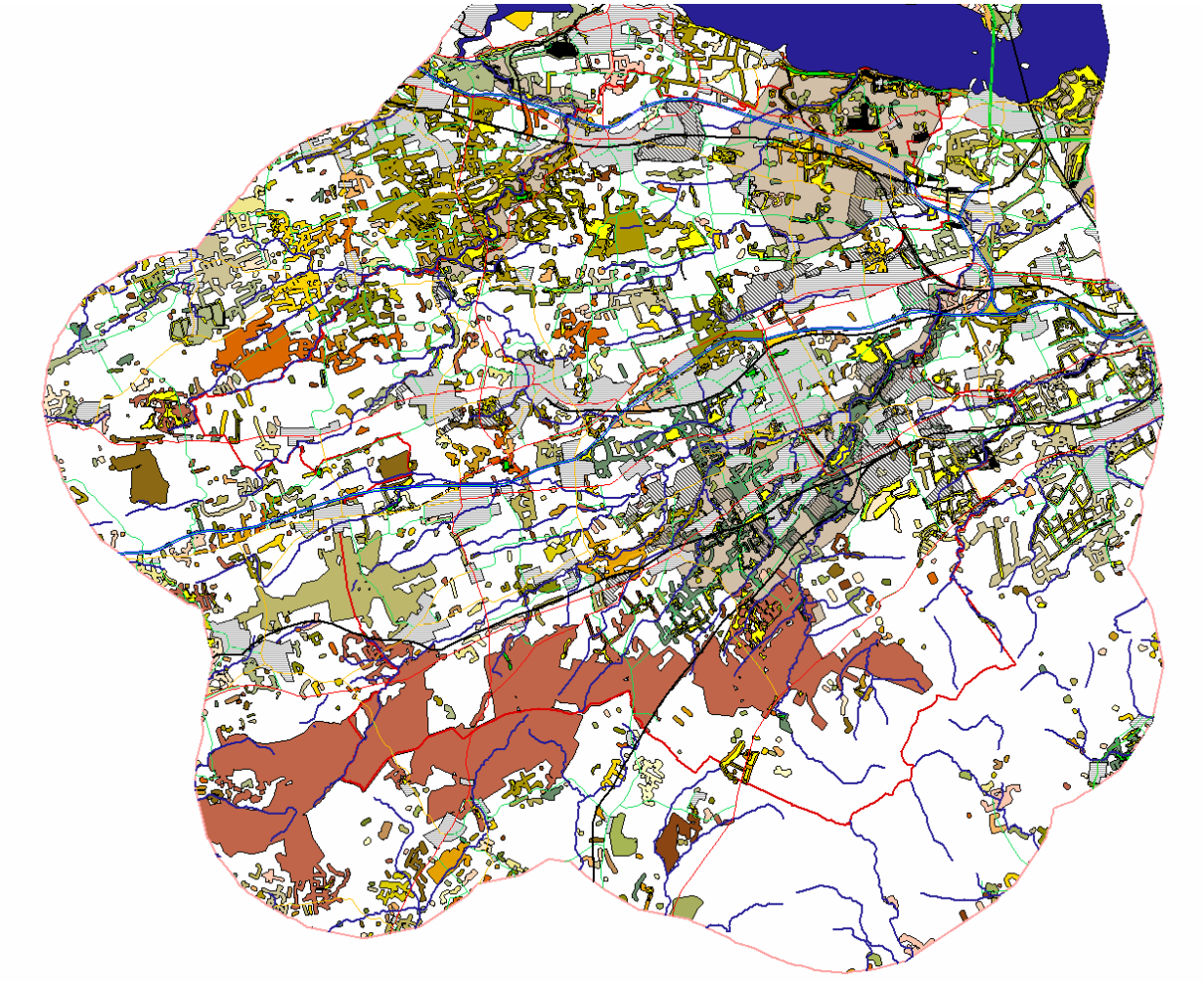
Woodland Ecology Branch
Forest Research



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Commissioned Report Summary

Development of a Forest Habitat Network Strategy in West Lothian
Report No. AB(LJ15)0304118 to Scottish Natural Heritage
Contractor: D Ray & J Hope Woodland Ecology Branch, Forest Research

Background

West Lothian currently has over 6500 ha of woodland (approximately 14% of the land cover), most woodland is coniferous and of plantation origin. The Ancient and Semi-Natural Woodland (ASNW) Inventory lists only 316 ha in the county, most of which is concentrated in three areas associated with the Rivers Almond, Avon, Linhouse Water and Murieston Water in small fragmented blocks. The West Lothian Biodiversity Action Plan suggests 8 action points to maintain and enhance woodland biodiversity and expand the woodland area: identify and map sites, survey important woodlands, encourage restoration and good management, plan conservation management, train planners, expand woodlands by natural regeneration and planting, encourage new woodland planting and develop and promote forest habitat networks.

This report addresses a number of the LBAP action points. The concept of Forest Habitat Networks is developed to focus woodland management and expansion with the objectives of woodland species conservation in mind. A generic focal species approach is used to identify key woodland habitat within wider, functionally linked, networks. The approach allows the identification of areas where woodland expansion could provide important stepping stones to facilitate dispersal of woodland species. An Ecological Site Classification analysis has been used to indicate the types of woodland expansion in key areas and its suitability as habitat for priority species, and species of conservation concern, mentioned in the West Lothian LBAP. The expansion options are discussed in context of the local plan, urban areas and the importance of open habitats.

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1. Executive Summary

1.1. This report describes a GIS based desk study to identify the semi-natural woodland framework for the development of a Native Woodland Habitat Network in West Lothian. The work identifies the core woodland areas of high biodiversity. It discusses a focal species approach to understanding and testing the landscape patch mosaics for the conservation of woodland biodiversity. It examines and discusses the likely effect of native woodland expansion on key open-habitats and the associated biodiversity. Finally, it examines and discusses conflicts between the need for woodland expansion in areas designated for development in the West Lothian Local Plan.

1.2. The SFGS includes a section designed to encourage the management and expansion of native woodland Forest Habitat Networks, through natural regeneration, planting, conversion and restoration. The SFGS Applicants Booklet suggests that 90 percent grants may be available where new native woodland is established or restored within 300 m of existing ancient semi-natural woodland. This work shows where this expansion should be prioritised and concentrated to develop and deliver a native woodland habitat network throughout West Lothian.

1.3. Only small remnant blocks of ancient semi-natural woodlands remain in West Lothian, amounting to about 540 ha. Categories of ancient woodland and plantations on ancient woodland sites were identified in three Core Ancient Woodland Areas (CAWA), the Avon Valley, the Hopetoun woodlands and the Calder woodlands in the Almond valley.

1.4 The distribution of fifteen vascular plant ancient woodland indicators from the Flora of the Lothians Survey matched the location of the ancient woodland "hot-spots" shown by the Ancient Woodland Inventory. This also confirmed that the remnant patches of ancient woodland in West Lothian still contained dispersal limited core-woodland plant species.

1.5. Using very broad scale Scottish National Digital Soil Sub-Group data (scale of 1:250,000) and British Geological Survey solid geology and drift lithology (scale 1:50000), the ESC soil quality was estimated. An analysis using the ESC-GIS woodland HAP model indicated that over much of the lowland area of West Lothian, lowland mixed broadleaved woodland was suitable. To the south of the county on lower slopes of the Pentland Hills, the soil quality and climate changed to show, in a general sense, upland oak-birch woodland and wet birch woodland was suitable. A site based survey should always be carried out to ensure the tree species for the planned woodland are suited to site conditions.

1.6. A Forest Research prototype landscape ecology model 'BEETLE' (Biological and Environmental Evaluation Tools for Landscape Ecology) was used to assess the spatial position and extent of functional habitat networks, based on broad habitat types from a phase 1 habitat survey. Networks were defined, for woodland species and open species, as contiguous areas containing functionally connected habitat patches in a matrix. A network is defined as a landscape structure through which focal species can disperse freely between numerous habitat patches.

1.7. Four generic focal species profiles were tested in the BEETLE model. A list of nationally rare woodland species, for which the local Biological Records Centre had recorded in West Lothian, was drawn up. The species were classified in terms of there area requirements and dispersal ability. The list includes several dispersal limited woodland specialists. Accordingly, a dispersal limited broadleaved woodland generic focal species was included in the analysis as a realistic test of the functionally connected areas of woodland. A dispersal limited woodland generalist and a dispersal non-limited woodland generalist were also examined. Small forest habitat networks suitable for dispersal limited woodland specialists occurred particularly within the 3 CAWA. The woodland generalist networks were also associated with the 3 CAWA, and functional connectivity between woodland habitat decreased in the central parts of the county. The dispersal non-limited woodland generalist network was widespread across the county.

1.8. The report suggests those areas where new native woodlands and the expansion of existing woodlands should be concentrated to facilitate the FHN for the county.

1.9. The development plan was intersected with the FHN maps and areas of potential conflict, and possible solutions to facilitate the FHN suggested.

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2. Objectives

The overall project objective is to provide a Forest Habitat Network strategy for West Lothian. This strategy will identify priorities for woodland restoration and expansion by increasing the functional connectivity of the woodland resource. Operational objectives may be summarised as follows:

2.1. Identify selection of focal species and core areas for these species.

2.2. Identify key areas for native woodland restoration and expansion in order to functionally link West Lothian's core woodland habitats for focal species.
2.3. Identify key open habitats, and the network links that will maintain the ecological function and viability of those habitats.
2.4. Identify land-use conflicts between woodland expansion and open habitat conservation.
2.5. Identify conflicts between key habitat networks and development proposals.

3. Background

3.1. General

3.1.1. There is an increasing imperative to conserve biological diversity and ensure its future viability and integrity. In the UK, the conservation of biodiversity has historically been based on the protection of a series of small, isolated sites; however, continuing declines in biodiversity indicate the ineffectiveness of this approach. Within a highly fragmented landscape, such as much of lowland Scotland, there is an increasing recognition of the importance of including the surrounding 'wider countryside' in future conservation strategies, and this has facilitated a more holistic view of biodiversity conservation at much larger spatial scales.

3.1.2. A potentially powerful method of addressing conservation of woodland biodiversity at the landscape scale is through the development of Forest Habitat Networks (FHNs). It is recognised that woodland expansion targeted according to FHN strategies of linkages and corridors will conserve forest biodiversity by reversing the consequences of woodland fragmentation and habitat loss. (Bennett, 2003; Peterken et al., 1995) In general, the concept of a FHN should promote:

- Retention of ancient woods, improvement of their condition, and buffered expansion to reduce edge effects;
- Creation of large woods and well-wooded districts;
- Locate new woodland next to existing woodland to minimise isolation;
- Improve 'matrix' quality (i.e. non woodland) by restoring scrub and other semi- natural habitat.

3.1.3. The Scottish Forestry Strategy has identified that native woodland expansion should be targeted towards the development of FHNs. The Scottish Forestry Grant Scheme (SFGS) provides some financial support to help meet these

objectives. To qualify for 90% grant aid towards establishment costs, new native woodland should be located within 300 m of existing native woodland, or within 300 metres of plantation woodland on ancient woodland sites (PAWS) for which restoration is planned. In addition, any new native woodland should contribute to woodland Habitat Action Plan expansion targets and/or objectives and should be suited to the site conditions, based on an assessment of the site potential.

3.1.4. In West Lothian, because of the scattered distribution of 'semi-natural' woodland in the Scottish Semi-Natural Woodland Inventory (SSNWI), a liberal reading of the SFGS rules might allow 90% funding for native woodland expansion over large areas of the county. Fortunately, in West Lothian, a good quality Phase 1 habitat survey has been digitised. This allows a survey-based assessment of land-use, and semi-natural woodland in particular, in the county. The prioritisation for woodland expansion is required to ensure cost-effective delivery of grants, so that new woodland is located where it will provide the greatest benefit for biodiversity given other constraints. In addition, in West Lothian there are significant pressures on land for both development and agriculture, and it is essential to identify areas where potential development may have a negative impact on the functioning of the habitat network.

3.1.4. West Lothian currently has over 6500ha of woodland (approximately 14% of the land cover), most woodland is coniferous and of plantation origin. The Ancient and Semi-Natural Woodland (ASNW) Inventory lists only 316ha in the county, most of which is concentrated in three areas associated with the Rivers Almond, Avon, Linhouse Water and Murieston Water in small fragmented blocks. The West Lothian Biodiversity Action Plan suggests 8 action points to maintain and enhance woodland biodiversity and expand the woodland area:

- identify and map sites,
- survey important woodlands,
- encourage restoration and good management,
- plan conservation management,
- train planners,
- expand woodlands by natural regeneration and planting,
- encourage new woodland planting,
- develop and promote forest habitat networks.
-

3.1.6. From an initial consideration of the role and spatial arrangement of FHNs, many of the action points of the LBAP list can be addressed.

3.2. Landscape ecology based tools

3.2.1. An important, emerging basis for understanding the nature and dynamics of the wider countryside is now provided by landscape ecology. This subject helps us explain, predict and plan change in the wider countryside, focussed as it is on patterns and ecological process within entire landscapes. Land use plans and indicative strategies based on these ecological principles are finding increasing application, especially in Europe and the USA, and more recently the UK. This reflects a growing maturity in landscape ecology, enabling it not only to inform theory, but also offer solutions to 'real world'

planning problems. For example, since the appropriate data are not usually available to examine the distribution and utilisation of a landscape by a particular species, there has been a move to develop and use ecological tools that are independent of actual species data. Such tools can assess the landscape pattern for the potential to conserve biodiversity by assessing in general terms the cohesion of habitat patches, and of habitat networks, in the landscape (Opdam and Pouwels, 2003) from generic species profiles.

3.2.2. We have adopted a generic focal species modelling approach in this study. In order to assess the landscape from a species-based perspective, we have used the Forest Research prototype GIS-based Decision Support System (BEETLE - Biological & Environmental Evaluation Tools for Landscape Ecology), which is based upon the landscape requirements for a range of focal species. (Watts, 2003) The suitability of this approach has been recommended by Hawkins and Selman (Hawkins and Selman, 2002) who stated that "one of the most serious practical difficulties facing landscape ecologists when advising on the re-design of landscape elements is that there is no single optimum design that suits 'biodiversity' generally, as each species has distinctive spatial requirements". The generic focal species idea builds on the concept of an umbrella species, whose requirements are believed to encapsulate the needs of other species and ecological processes (Lambeck, 1997). In this study, generic focal species have been selected to represent different woodland types (e.g. conifer and broadleaved) and habitats (e.g. edge and interior) and in particular the ecological processes of these combinations. They do not encapsulate precisely the varying degrees of sensitivity to habitat modification and fragmentation of individual species. However the method does offer the opportunity to focus on how actual (real) species may be affected by landscape change. According to the underlying theories, the sensitivity of a species to habitat fragmentation is linked to the area requirements and dispersal ability of the species (Table 3.2.1). It must be emphasised, that focal species should be regarded as part of the evaluation toolkit and not necessarily direct targets themselves. It may also be prudent to select a number of non-woodland focal species to ensure open habitat networks are not compromised, by the establishment of a woodland habitat network, and ensure an effective balance is achieved. (Humphrey et al., 2003)

Table 3.2.1 Species sensitivity to habitat fragmentation

	Short dispersal distance	***Medium dispersal distance***	***Large dispersal distance***
Large area requirements	High extinction - low colonisation Highest fragmentation sensitivity		High extinction – good colonisation
Medium area requirements		Moderate extinction - medium colonisation	
Small area requirements	Low extinction – low colonisation		Low extinction - good colonisation Lowest fragmentation sensitivity

3.2.3. The BEETLE system is grounded in island biogeography and metapopulation theory, and draws from recent developments in landscape ecology evaluation tools (Opdam et al., 2002; Opdam and Pouwels, 2003; Verboom et al., 2001; Vos et al., 2001) which aim to enhance the evaluation of landscape pattern and processes. Basically stated, landscape modification and fragmentation will cause a change, either positive or negative, to habitat area and patch isolation. These two components of habitat modification and fragmentation relate to the local extinction risk of species on small patches and the colonisation ability of species on isolated patches. It is believed that these components can be characterised and evaluated by assessing the carrying capacity (based on patch area and quality) and functional connectivity (based on both distance and landscape permeability) of the habitat patches within the landscape, respectively. The latter concept, functional connectivity, can only be assessed relative to the ability of a focal species to move about a landscape. It is thus a separate concept to structural connectivity (or contiguity), which is independent of any species characteristics.

4. Methods

4.1. Data

4.1.1. The following spatial datasets were used in this study:

- Phase 1 Habitat Survey of West Lothian (P1)
- Land Cover Map 2000 (LCM)
- Ancient Semi-Natural Woodland Inventory (ASNWI)
- National Inventory of Woodlands and Trees (NIWT)
- Scottish National Digital Soil Map (MLURI)
- Plant distribution data from Flora of the Lothians Project (FLP)
- OS Strategy infrastructure data (roads, railways and urban areas)
- Ordnance Survey Digital Elevation Model (DEM) for the ESC climatic and soil quality indices.
- British Geological Survey 1:50 000 digital maps, (BGS)

Given the availability of Phase 1 habitat surveys for West Lothian, it was unnecessary to use LCM2000 data in this study.

4.2. Woodland Core Areas

4.2.1. The development and designation of a FHN which links core woodland areas, (Peterken et al., 1995) requires that the ‘nodes’ should be identified, and managed sensitively. The core areas will maintain high woodland biodiversity currently within the county, and can be considered refugia, from which elements of the future woodland biodiversity throughout the FHNs will evolve in the long term (centuries). This does not necessarily mean that all new or restored woodland will be suitable for all woodland species. However the core areas should be of sufficient size, and managed sympathetically, to

ensure that dispersal limited woodland specialist populations will persist long enough to expand into suitable areas of the FHN.

4.2.2. Scotland's Ancient Woodland Inventory depicts woods that are either of semi-natural origin or of plantation origin; and also of 'Ancient' antiquity, dating from either 1750 (occurring on the 'Roy' maps and all maps since) or of 'long-established' antiquity dating from 1860 (occurring on the first edition map of the Ordnance Survey and all maps since). Figure 4.2.1 shows the distribution of woodland in West Lothian classified as ancient and long-established, as well as the ancient woodlands now re-planted. The ancient woodland sites have had at least 250 years of continuous woodland cover, and even if recently replanted will continue to have high biodiversity of dispersal limited species. Three core ancient woodland areas (CAWA) in West Lothian and the one neighbouring CAWA in Edinburgh City Council Area are suggested by this distribution, and shown on each of the detailed maps (Figures 4.2.2-4.2.5):

- the Avon (Muiravonside Country Park – north to Linlithgow and west towards Grangemouth)
- the Hopetoun area including, The Binns, Philpstoun House, Duntarvie Castle, Dundas Castle and Mounthooly.
- Calder Wood and the woodlands of the Almond and Murieston Burn
- Dalmeny Park (although outside West Lothian – this is an important core area within the 5 km buffer zone)

Other important woodland areas such as Roslin Glen and Penicuik Estate may also connect with the West Lothian FHN in time.

4.2.3. Vascular plants have been used as indicators of both habitat quality, (Ellenberg, 1988; Wilson et al., 2001) and of habitat age or continuity. (Peterken, 1974; Spencer, 1990) Field survey and floristic study has provided a list of ancient woodland indicator plants (Rose, 1999)that support woodland antiquity in four regions of southern Britain. This list contains plants which take centuries to colonise woodland. Studies by (Peterken, 2000) have shown that these plant communities are mainly associated with ancient categories of woodland (even though not all are shade tolerant woodland specialists), not being present in more recent plantations of a given woodland type. Species occurring on the list have not been tested as indicators of ancient woodland in West Lothian, but we have made the assumption that these species will have a similar ecology in West Lothian, to other regions of Britain. Further supporting evidence for these plant indicators of ancient woodland is given by Smith (Smith et al., 2002).

4.2.4. The Botany of the Lothians project (Smith et al., 2002) provides information on the distribution of plants occurring within a 2km square grid across West Lothian. Figures 4.2.6-4.2.9 show the distribution of 15 ancient woodland indicator plants in West Lothian and the 5 km buffer (Table 4.2.1). There is good correspondence between the ancient woodland core areas and the plant distribution, suggesting that ancient woodlands provide habitat suited to dispersal limited plant species.

Table 4.2.1. List of ancient woodland indicator plants found in parts of West Lothian

Species (common name)	Species (scientific name)
Moschatel	Adoxa moschatellina
Lord's-and-Ladies	Arum maculatum
Giant Bellflower	Campanula latifolia
Pendulous Sedge	Carex pendula
Enchanter's-nightshade	Circaea lutetiana
Giant Fescue	Festuca gigantean
Snowdrop	Galanthus nivalis
Woodruff	Galium oderatum
Wood Millet	Milium effusum
Wood Meadow-grass	Poa nemoralis
Common Wintergreen	Pyrola minor
Wood Dock	Rumex sanguineous
Sanicle	Sanicula europaea
Chickweed-wintergreen	Trientalis europaea
Lesser periwinkle	Vinca minor

4.3. Model parameterization

4.3.1. Table 4.3.1 shows a list of species of local conservation concern, identified by: the West Lothian Biological Records Centre, the Flora of Edinburgh and the Lothians Project, and by the Local Biodiversity Action Plan Group. Dispersal abilities and the minimum area requirements for these species are assessed. This will provide a taxonomic link to the three generic woodland focal species and the generic open-habitat generic focal species profiles specified in Table 4.3.2 that have been used in this study:

a) dispersal limited woodland specialists
b) dispersal limited woodland generalists
c) dispersal non-limited woodland generalist

Table 4.3.2. Functional relationship of generic focal species profiles

		Dispersal ability		
		Low	**Moderate**	**High**
Area requirements	**High**	a)Woodland Specialist b) Woodland Generalist		Woodland Specialist Woodland Generalist
	Moderate		d) Wet grass/heath generalist	
	Low	Woodland Specialist Woodland Generalist		Woodland Specialist c) Woodland generalist

4.3.2. The generic species profiles were parameterised such that dispersal limited species could move up to 1 km in habitat, increasing to 5km for high dispersers. This dispersal ability was reduced in the surrounding matrix by applying a dispersal cost associated with the broad habitat type of each patch. For specialists, costs of 2 were applied to conifer and mixed woodland, allowing a maximum dispersal distance of 500 m in non-broadleaved woodland. The range of costs varied from 1 (broadleaved woodland) to 50 for urban areas and 100 for water (thus effectively defining a barrier to dispersal. Woodland specialists were assumed to require broadleaved woodland habitat and were sensitive to the woodland edge. This was achieved in the GIS by internal buffering by 2 tree heights (50 m) from the woodland edge. Generalist habitat included broadleaved, conifer and mixed woodlands, and the generalists were not sensitive to woodland edge conditions. Generalists were subject to a similar range of dispersal costs for various broad habitat patch types.

Table 4.3.1. Some rare red data book woodland species, UKBAP species and LBAP species occurring in West Lothian

Species	Common name	Habitat requirements	Dispersal ability	Area requirement	Woodland Specialist or Generalist
Stiroma bicarinata	a planthopper	Vegetation in woodland.	low	small	S
Wesmaelius malladai	a brown lacewing	Pine forest.	medium	small	S
Acrotrichis lucidula	a featherwing beetle	Wet moss by spring water seepages and trickles in woodland. Also found in fens, in Alder carr and other damp places.	medium	small	G
Curculio villosus	a weevil	Broadleaved woodland - A parasite of oak gall wasps	medium	medium	S
Judolia sexmaculata	a longhorn beetle	Old pine woodland	low	small	S
Luperus flavipes	a leaf beetle	Broadleaved woodland (BLW), parkland, scrub, heath and disused railway lines.	medium	small	G
Lampronia fuscatella	a longhorn moth	Ancient birchwoodon peat with a continuous history of regeneration (trees < 10 years old)	medium	medium	S
Limnophila pulchella	a cranefly	Boggy areas, especially in woodland with patches of Sphagnum or exposed peat. Larvae probably develop in damp peat or moss.	medium	small	S
Limnophila verralli	a cranefly	Near small streams, usually in the shade of alders. Larvae aquatic.	medium	small	S
Limonia trivittata	a cranefly	Wet woodland on calcareous soils, especially near rivers.	medium	small	S
Molophilus corniger	a cranefly	Woodlands with seepages.	medium	small	S
Tipula pseudovariipennis	a cranefly	Mainly calcareous woods.	medium	small	S
Dicrostema gracilicornis	a sawfly	Larva on Adoxa moschatellina	low	low	S
Turdus philomelos	Song Thrush	Woodland, broad-leaved & mixed	high	medium	G
Muscicapa striata	Spotted Flycatcher	Woodland, broad-leaved & mixed	high	medium	G
Passer montanus	Tree Sparrow	Tree-lines	high	medium	G
Pyrrhula pyrrhula	Bullfinch	woodland, broad-leaved & mixed	high	medium	G
Sciurus vulgaris	Red Squirrel	Mainly large blocks (>50ha) of mature coniferous forest, particularly Scots Pine.	medium	medium	G
Meles meles	Badger	Mostly lowland, lightly wooded countryside. Setts most often in woods and copses, hedgerow and scrub.	medium	medium	G
Amanita submembranacea	a fungus	Woodland	low	small	G
Anemone nemoralis	Wood Anemone	Woodland	low	small	S
Asio otus	Long-eared Owl	Woodland and neighboring open country	high	large	S
Betula pubescens	Downy Birch	Woodland			
Fagus sylvatica	Beech	Woodland			
Melampyrum pratense	Common Cow-wheat	Open woodland	low	small	S
Picus viridis	Green Woodpecker	Open deciduous woodland	high	medium	G
Scirpus sylvaticus	Wood Club-rush	Woodland	low	small	G
Tetrao tetrix	Black Grouse	Woodland edge	high	medium	G
Usnea filipendula	a lichen	Conifer and birch woodland on exposed and acidic sites	low	small	S

4.3.3. The land cover matrix was defined within a GIS using digitised Phase 1 Habitat surveys (P1) for West Lothian and also within a 5 km buffer area surrounding the county boundary in Edinburgh City, and Midlothian. Because there was no P1 for other surrounding counties, the open-land matrix patches within the buffer area in Falkirk District and Scottish Borders were set using the Land Cover Map 2000 (LCM) (from the LandSAT multi-spectral imagery) while woodland patches were defined using the National Inventory of Woodlands and Trees (NIWT). Figure 4.3.1 shows the composite land-use matrix for West Lothian and the 5 km surrounding buffer. The blank areas of Figure 4.3.1 represent non-surveyed areas under intensive agriculture, either improved pasture or arable.

4.3.4. The 3 selected focal species were matched against non-habitat (matrix) land cover types in terms of landscape permeability. An accumulated cost distance buffer was calculated around each habitat patch, and where two or more adjacent cost distance buffers intersected, the areas of adjacent habitat were considered to be functionally connected within a single habitat network.

4.3.5. The area requirements of generic focal species were set arbitrarily assuming that area limited species require a minimum of 10 ha of habitat to maintain a viable population, whereas species not sensitive to habitat area could maintain a viable population in 2 ha. The minimum area of habitat could be comprised from a single patch or several functionally connected patches. The focal species area requirement was therefore assessed by measuring the total amount of habitat within each functionally connected network.

4.3.6. An assessment of soil quality was made from the Scottish National Digital Soil Map with some soil quality adjustments for lithology from the 1:50000 British Geological Survey, digital data set. Climate data was calculated using ESC climate models and data from the Ordnance Survey Digital Elevation Model (DEM). This allowed a broad assessment of woodland HAP type suitability in West Lothian.

5. Results

5.1. General

5.1.1. West Lothian county (including a 5 km buffer surrounding the county) has over 14 000 ha of woodland, over 9000 ha of which is conifer plantation, and 4664 ha of broadleaved woodland in 4000 woodland patches. About 540 ha (108 patches) of the broadleaved woodland is classified as ancient in the ASNWI. The broadleaved woodland therefore represents about one third of the woodland area, of which nearly 4% is of ancient origin. By comparison this is a significantly greater proportion of broadleaved woodland, and of ancient woodland, than occurs in the Scottish Borders to the south.

5.1.2. The Scottish Semi-Natural Woodland Inventory (SSNWI) shows semi-natural woodland is well distributed across the county (Figure 5.1.1). The application of a 300m buffer surrounding these blocks shows that new native woodland could qualify for 90% SFGS funding almost anywhere in the county. The emphasis of this report is therefore to prioritise where the woodland expansion and restoration should be targeted to make an initial FHN impact.

5.1.3. Woodland of the Avon CAWA has a riparian and gorge woodland character, which differs from the Almond woodlands with a more rural setting. The Avon Valley lies on the Coal Measures of the Carboniferous Series, giving rise to silty-loam textured soils, of Medium to Rich SNR in valley woodlands. Away from the valley soils have developed in diamicton drift, which are likely to be of Medium SNR. For lithology and soil quality distribution maps see Appendix 2.

5.1.4. Hopetoun differs from the Avon and Calder CAWA in respect of the extent of ancient woodland in parkland and in private estates of castles and country houses. The CAWA lies on the West Lothian Oil shale Series (Appendix 2), with a drift lithology of mainly diamicton and richer marine clay deposits. The soil quality is likely to be Medium to Rich with occasional Very Rich soils associated with clay.

5.1.5. Each of the core ancient woodland areas of West Lothian show differences in either geography, topography or lithology. The Calders CAWA certainly contrasts the Avon and Hopetoun CAWA areas by its proximity to the urban fringe of Livingston and surrounding villages, in which the ancient woodland patches are intimately juxtaposed with the urban area. Soils have largely developed on the diamicton lithology of Carboniferous origin, and are generally of Medium SNR, but richer where the rivers cut through into gorges on the underlying Carboniferous sediments.

Dispersal limited woodland specialist networks

5.2.1. This analysis is the most rigorous test of habitat fragmentation, since it measures the habitat network connectivity of sedentary ‘core woodland’ specialists. The particular species of local importance and rarity that fit in this focal species category would include *Stiroma bicarinata, Judolia sexmaculata,*

Dicrostema gracilicornis, Anemone nemoralis, Melampyrum pratense and Usnea filipendula (Table 4.3.1). Appendix 3 near the end of the report provides a fold out legend for the P1 habitat types. Each of the three Core Ancient Woodland Areas (CAWA) of West Lothian is considered separately.

5.2.2. Over four hundred habitat patches suitable for broadleaved woodland specialists occur in West Lothian and its 5 km buffer. This habitat is connected in 227 separate habitat networks (Figure 5.2.1).

Avon Core Ancient Woodland Area

5.2.3. Figure 5.2.2 shows a detailed map of the dispersal limited woodland specialist networks in the Avon CAWA. Habitat and the P1 matrix are shown above, whereas the functionally connected habitat networks and the Local Plan development areas are featured in the lower map. P1 data is not available for Falkirk District.

5.2.4. For the woodland specialist focal species habitat was internally buffered broadleaved woodland (a 50m internal buffer was applied to remove edge effects). The networks shown in the lower part of Figure 5.2.2 link all habitat, according to the habitat dispersal costs of the surrounding matrix.

5.2.5. The small ancient woodland remnants of the Avon Valley support habitat for dispersal limited woodland specialists. An assumption can be made that particularly high quality ancient woodland occurs at Carriber Glen SSSI. However, the woodland is sparsely distributed and, for more demanding (sedentary) woodland obligate species, the network may not connect.

5.2.6. Suitable habitat is missing north of Whitecross through to Linlithgow. Consequently the Muiravonside woods are not functionally connected to the habitat networks of the lower Avon north west of Linlithgow (Avon Gorge SSSI), in Falkirk District.

5.2.7. Note however the amount of woodland habitat within the Avon CAWA meets the 10 ha minimum threshold for area restricted focal species. Compare this network with the surrounding habitat networks in and surrounding Beecraigs Country Park. Only the Longmuir plantation network meets the 10 ha habitat threshold.

5.2.8. The main Local Plan development area is to the east of Linlithgow and is not close to the dispersal limited woodland specialist networks of the Avon CAWA.

Hopetoun Core Ancient Woodland Area

5.2.9. The Hopetoun CAWA contains several ancient woodland remnants some of which form habitat for dispersal limited broadleaved woodland specialists (Figure 5.2.3), including one woodland SSSI (Philpston Muir). Although several woodland habitats form small networks, it is quite clear that the individual private woodland estates are not functionally connected for this focal species. The surrounding matrix is mainly of non-P1 habitat (which we assume is arable or improved grassland). There are some small woodland

blocks between Midhope and Hopetoun which, if enlarged, could serve as stepping stone habitat to connect the two large networks of the Hopetoun CAWA.

5.2.10. Several other networks occur in the Hopetoun CAWA, but they support smaller habitat areas (2-10ha). However they are positioned close to one another and distributed in such a way that, with some woodland habitat enlargement and new stepping stone woodland blocks, the intervening farmland could easily connect up these small networks to the main Hopetoun and Midhope networks.

5.2.11. To the east of the Hopetoun CAWA lies Dundas Castle woodland network, comprising suitable habitat for dispersal limited woodland specialists. Although this network is outside the remit of the West Lothian Council Area, this important woodland network is situated between the Hopetoun CAWA and the Dalmeny Park CAWA of Midlothian. Linkages between these major broadleaved woodlands should be a priority, and could be achieve by expanding existing woodland blocks, and restoring others to broadleaved woodland, to form a more extensive Lothian-wide FHN.

5.2.12. To the south of the Hopetoun CAWA lies the woodland surrounding Mounthooly and the Union canal. This network is long and narrow and should be broadened to 150m width wherever possible to provide more core-woodland habitat

5.2.13. Linkages between the Hopetoun woods could be made at Philpstoun House, and to the Carmelhill woods by expanding new native woodland either side of the railway line and M9 motorway at Myre. If the major proposed LAP development north of Winchburgh incorporated new native woodland (at least 150m wide to allow a 50m wide core-woodland habitat) on its northern boundary, then the future FHN connecting up the Hopetoun CAWA with Dundas Wood in Midlothian would be secured.

Calders Core Ancient Woodland Area

5.2.14. The Calders CAWA is supported by 10 or so woodlands within the valleys of the River Almond, Murieston Water and Linhouse Water, with the addition of a few woodlands scattered between these valleys (Figure 5.2.4).

5.2.15. The main concentration of habitat for dispersal limited woodland specialists is in Mid Calder, based around Calder Wood Country Park from Murieston north to Almondell. Despite its proximity to the urban fringe of Livingston and surrounding villages, the CAWA supports the high-biodiversity woodlands of Calder Wood SSSI and Hermand Birchwood SSSI, with the additional protected sites of Linhouse Valley SSSI and Hermand Quarry. Additional woods with small networks and less core habitat (2-10ha) include the Bellsquarry and Newpark network, Broomhill and Harburn Network (south-east of West Calder), and Cousland Wood between Seafield and Livingston.

5.2.16. Calder Wood Country Park contains partly fragmented core-woodland habitat, and attempts should be made to expand these woods with native tree species, to consolidate core woodland-interior conditions. The long term

resilience of the ancient semi-natural woodland SSSIs would be improved by buffered expansion to reduce edge effects.

5.2.17. New native woodland should be expanded west of Blackraw Farm to connect the network of Calder Wood with Murieston Wood along the Linhouse Water (Figure 5.2.5). Parts of the new woodland should be 150m or more wide to create core woodland conditions in the long term future. This could help achieve a more robust network for dispersal limited species.

5.2.18. A substantial buffer area of woodland is required to protect the small core woodland area of the Murieston Wood (Figure 5.2.5). The effect of urban expansion along the edge of the woodland could be devastating for broadleaved woodland specialists. Core woodland conditions are rare in the Calder CAWA networks and must be protected from edge effects, to maintain high biodiversity for woodland specialists.

5.2.19. Woodland expansion (both buffered and expansion) is also required south of Calder Wood SSSI along the Murieston Water to Nether Williamston, possibly across neutral unimproved grassland (Figure 5.2.5). The woodland of Nether Williamston should be carefully restored to expand the small area of core woodland conditions. Such an expansion and restoration would help maintain resilience of woodland biodiversity within the Murieston Water network.

5.2.20. The planned development on land south of Murieston across to the Lockerbie railway line (Figure 5.2.5) could seriously damage the existing dispersal limited species network in woodland close to the Linhouse Water, south of Murieston. This piece of land could provide a key connection to link broadleaved woodland habitats within a bigger network between the Calder CAWA and Selm Muir Wood and, in time, perhaps connect to the Over Williamston Woods and Camilty Plantation to the south.

5.2.21. With some expansion the Bellsquarry, Newpark and Brotherton Woods (at Adambrae) could be linked into a network, and indeed linked to the Murieston Network with new native woodland stepping stones, and corridors, along the Glasgow railway line.

5.2.22. Finally, to the north of Mid Calder and east of Livingston, woodlands from Clapperton, north along the Almond to Newbridge, form a network of small woodland habitats. The expansion and linkage of these woodlands should be a priority between the Visitor Centre and Clifton Hall, on both sides of the River Almond. The proposed development of Clapperton Hall should include substantial plantings of new native woodland to secure and maintain the habitat network between Drumshorelandmur and the Almond network.

5.3. Dispersal limited woodland generalist networks

5.3.1. All woodland types, including the woodland edge is assumed suitable habitat for dispersal limited woodland generalist focal species. The particular species of local importance and rarity that fit in this focal species category would include: *Wesmaelius malladai, Curculio villosus, Lampronia fuscatella, Limnophila verralli, Limonia trivittata, Molophilus corniger and Tipula pseudovaripennis*.. Appendix 3 near the end of the report provides a fold out

legend for the P1 habitat types. Each of the three Core Ancient Woodland Areas (CAWA) of West Lothian is considered

5.3.2. In general, the generalist woodland habitat connects up well in some areas (Figure 5.3.1), particularly the Avon Valley and the Murieston Water networks. Fragmentation is a problem within the central parts of the county where woodland blocks tend to be isolated in an agricultural landscape.

5.3.3. Over 5500 woodland habitats occur in West Lothian and the 5km buffer area surrounding the county boundary. These are connected into 1300 forest habitat networks.

Avon Core Ancient Woodland Area

5.3.4. The Avon Valley CAWA forms part of a large network with the wooded farmland between Avonbridge, Madiston and Westfield in Falkirk District Figure 5.3.2). Woodlands to the east of Muiravonside also forms a tenuous network for woodland generalists with the conifer woodland of Beecraigs Country Park. The links with Beecraigs should be improved by expanding woodland between Craigend and Beecraigs to the east and between Craigend and the Avon woods to the west.

5.3.5. The network to the south of Linlithgow through Beecraigs could be developed to form a link with the Hopetoun CAWA. This would be across farmland by expanding the rudimentary structure of stepping stone woodlands between Beecraigs and Philpstoun. The planned development to the south and east of Linlithgow might include new native woodland on its southern edge, linking the existing woods of Parkley and Hillhouse to Kings Cavil and eventually to Philpstoun for woodland generalists.

5.3.6. South of Beecraigs, new woodland expansion should be encouraged to link the Longmuir plantation, the Tartraven woods and several extensive woodland blocks north and north east of Bathgate, as well as the Dechmont woodlands west of Uphall. This would begin to form networks across the central farmland area of West Lothian.

5.3.7. North of Linlithgow a tenuous network extends across the eastern edge of Falkirk District almost linking the north Avon woods to the Wester shore wood of the Hopetoun CAWA. Strategic new planting between Waulkmilton and Grange, and between the Cauldcoats woodland and Wester Shore woods would begin to form the basic structure of this network. In addition existing woodland within the network should be broadened, to provide more core woodland habitat.

Hopetoun Core Ancient Woodland Area

5.3.8. Although the Hopetoun CAWA contains considerable ancient and semi-natural woodland, this is largely fragmented (Figure 5.3.3) even for dispersal limited woodland generalists. Figure 5.3.3 shows clearly the gaps between a number of small networks within the Hopetoun CAWA.

5.3.9. The priority should be to expand and link isolated patches of woodland between Hopetoun wood and Midhope wood. Also, the priority should be to expand and link the networks between Hopetoun and Dundas Castle via Duntarvie and Carmel Hill woods.

5.3.10. To the south of Hopetoun wood lies the network of Philpstoun and Mounthooly along the line of the Union canal. Woodland expansion from intersection 2 of the M9, west towards Philpstoun House, would probably begin to link up the two networks across this transport corridor.

5.3.11. If a substantial strip of native woodland along the northern edge of the planned development north of Winchburgh was planted, the Union canal network would be substantially improved. This would put in place a major section of missing woodland for a network to connect the Hopetoun CAWA and the Dundas woodlands. In addition, it would connect the Hopetoun woods with woods to the west of Kirkliston and Newbridge. This begins to form the woodland habitat network between Hopetoun CAWA and the Calders CAWA.

5.3.12. To the west of Uphall planned development would separate the Dechmont Woods from the Hopetoun CAWA. Again if the development included some substantial woodland along its northern edge, this would put in place a major section of the woodland habitat network to link with the Hopetoun CAWA.

5.3.13. Development plans at Burnside south-east of Broxburn could prevent linkage between the north Almond woods south of Newbridge and the Hopetoun CAWA. The incorporation of woodland on the eastern edge of this development would help form the woodland habitat necessary for establishing this network.

Calders Core Ancient Woodland Area

5.3.14. The Calders CAWA contains a single, riparian character network (Figure 5.3.4) through the Almond valley, running south from Newbridge in the north along the Murieston Water to Harburn in the south. The network could extend into the conifer plantations to the south of the Murieston Water, through Hartwood House woods.

5.3.15. New native woodland is required to bridge gaps in the network between the conifer plantations of Woodmuir and Camilty and the Almond –Muirieston-Linhouse Water Network. This should be targeted in the vicinity of the railway line at Balgreen and Blackhall, and at West Torphin, and around the south and west of West Calder. Proposed development at Balgreen (Skivo to Wellheads) will prevent the vital woodland corridor linkage between the southern plantations and the Calder CAWA.

5.3.16. Further new native woodland linkages are required to tie the Addiewell and Breich Water groups of woodlands into the Calders CAWA network to the west of West Calder at Addiewell. Proposed development north and west of West Calder would isolate the Addiewell and Breich Water woods from the Calders CAWA network. This development could also hinder the linkage of the Woodmuir plantation to the south,via the Addiewell woodlands, into the Calder CAWA network.

5.3.17. Woodland strips should be broadened where possible along the arterial route of the Calder CAWA network; ideally woodland networks should be a minimum of 150m in width. This will make the woodland habitat network more resilient to pressure from grazing, recreation and fly-tipping, as this is often concentrated at the woodland edges.

5.3.18. Three other proposed new development sites, at: 1. Brotherton, 2. Westfield, 3. Nether Williamston-Lockerbie railway line, will seriously fragment the woodlands at Brucefield, Murieston Castle Farm, and Selm Muir. These woodlands form a series of 'stepping stone' habitats that are essential to link the Woodmuir and Camilty plantation into the Calders CAWA.

5.3.19. Other proposed developments at Oakbank, and at the Almondell and Calder Wood Country Park Visitor Centre and opposite at Clapperton Hall could impinge on the CAWA network. If a substantial new native woodland buffer was used to separate the new development from the woodland habitat network this would ameliorate its impact.

5.3.20. One final proposed development site on the River Almond at Birdsmill House extends within the woodland habitat network. Again a buffer should be considered to lessen the impact of the development on the woodland habitat network.

5.4. Dispersal non-limited woodland generalist networks

5.4.1. This analysis is the least rigorous test of habitat fragmentation, since it measures the habitat network connectivity of mobile woodland generalists. Species falling into this category might include the woodland birds and mammals such as green woodpecker, tawny owl, badger and fox.

5.4.2. The upper map of Figure 5.4.1 shows the distribution of the 53 separate mobile generalist woodland habitat networks. The networks contain 5500 habitat patches, the same number as woodland generalist dispersal limited focal species networks. The main difference with this analysis is that 95% of all woodland habitat is connected in a single network.

5.4.3. With one exception, this analysis is of little value for identifying problems of ecological function in the landscape, as the landscape is functionally connected for mobile woodland generalists. The exception being that the roads, and in particular, the busy motorways can fragment networks for mobile land-based species. Figure 5.4.2 shows the effect of the three motorways on the functional connectivity of the West Lothian landscape to land-based mobile woodland generalist species. The upper map indicates that if the motorways do act as a barrier, then the woodlands of the county form 3 large networks and several smaller networks compared with the single network covering 95% of the woodland habitat of the county in Figure 5.4.1. The lower map of Figure 5.4.2 shows the size distribution of habitat included in each of the networks shown in the upper map. The main difference is a substantial reduction in the amount of woodland habitat included in the smaller FHNs surrounding Winchburgh, Kirkliston and Newbridge.

5.4.4. This analysis illustrates that even for a mobile woodland species the FHNs of West Lothian can still be fairly fragile in the vicinity of the main transport corridors through the county. The coupled issue of urban expansion and development on the one hand with busier wider roads networks on the other could seriously fragment woodland habitat in the county, leading to a serious loss of woodland biodiversity.

5.5. Dispersal limited open habitat generalist networks of wet grassland/heathland and mire

5.5.1. Figure 5.5.1 upper map shows individual open habitat networks for dispersal limited generalist species of wet grassland, heathlands and mires for West Lothian. Over 1800 patches of habitat, connected within 147 networks, are concentrated around the southern perimeter of the county, along the margins of the Pentland Hills (e.g. Miller's Moss, Fauldhouse Moor,Longridge Moss, Cobbinshaw Moss SSSI), and a few patches associated with the higher ground close to, and west of, Harthill and Blackridge (e.g. Blawhorn Moss SSSI) on the south western border with North Lanarkshire. Compare the upper and lower maps of Figure 5.5.1 to assess the size class of open habitat contained within individual networks. Three large networks (over 1000 ha) functionally connect wet open habitat for generalist species in the south and west of the county.

5.5.2. The largest network, surrounding the conifer plantations of Woodmuir and Camilty, extends over 15,000 ha, incorporates 640 patches of wet grassland, wet heath and mire habitat totalling 4,800 ha in area. Figure 5.5.2 shows how this open habitat network is spatially distributed around Hartburnhead and Camilty plantations in the centre of the map. It shows patches of open wet habitat within the woodland blocks, and these appear to be fragmented and isolated from the Cobbinshaw SSSI. One might conclude from this map that woodland can fragment valuable open habitat, and that woodland expansion is therefore bad for open wetland semi-natural habitat.

5.5.3. If the Calder CAWA FHN is to be linked into the conifer plantations to the south, woodland expansion will be required across open semi-natural habitats. Figure 5.5.3 provides a larger scale map of the Cobbinshaw SSSI – Hartburnhill plantation area. The phase 1 survey has identified patches of wet grassland, heathland and mire within the larger rides of the plantation. The BEETLE analysis demonstrates that small habitat patches can remain functionally connected to the main habitat outside the woodland through a wider forest ride network (Figure 5.5.4). This process has been confirmed in Clocaenog Forest in North Wales, where the ride system has been shown to functionally connect open glades of wet ground within the forest for the small pearl-bordered fritillary (*Boloria selene*).

5.5.4. There three broad areas where new woodland expansion will be required to link the southern plantations into the Calders CAWA: between Nether Williamston and Over Williamston; West Harwood to Hermand; and Addiewell to Woodmuir plantation. New native woodland expansion should take precedence over development. Proposed development will seriously damage the opportunity to form woodland networks between the Murieston and Linhouse Water woodlands of the Calders CAWA and the southern plantations. This is particularly important for the Williamston link, here

woodland expansion could be achieved without fragmenting wet open habitats. This is particularly important as there is a significant open habitat network within the Harwood – West Calder area and the Addiewell area.

6. Discussion

6.1.1. The concept of species conservation through habitat networks has developed rapidly throughout the last decade since the signing of the Convention on Biological Diversity. (UNCED, 1992) This has prompted a new international acceptance and emerging agreement of the need to conserve biological diversity using an approach which includes the planning, establishment and adaptive management of protected-area networks. (UNEP, 2003) The landscape ecology paradigm of patch, matrix and corridor was first introduced by. (Forman and Godrum, 1986) This mirrored the evolving ideas of 'greenways' (Smith and Hellmund, 1993) from within the discipline of landscape architecture. Research on the functioning of ecological networks in relation to the landscape patch mosaic occurs at a range of spatial scales, and has concentrated on the functional connectivity of habitat.

6.1.2. The adoption of FHNs across Scotland has been recommended by Scottish Natural Heritage (SNH). (Peterken et al., 1995) The rationale was to reverse fragmentation and rebuild significant areas of native woodland, primarily to conserve and enhance woodland biodiversity. They suggested that FHNs should exist at a range of scales, comprised of 'nodes' and 'links'. At the regional and national scales the nodes have been termed 'Core Forest Areas' (CFAs) and should be linked by well-wooded belts of countryside. At the local level individual woods or clusters of woods represent nodes. It is recognised that the development of FHNs will reverse native woodland fragmentation and link sub-populations. It has been argued (e.g. Peterken et al;1995) that this will maintain genetic contact both within and between meta-populations and, in turn, provide greater species resilience in times of external stress, such as climate change. The development of functional linkages in the landscape is the important measure, and a generic focal species approach, such as the BEETLE model, defines linkages for generic classes. The species of local conservation concern are then placed within those classes.

6.1.3. West Lothian contains a modest area of woodland, but it is distributed in a mix of several very large conifer blocks and many fragmented broadleaved patches. The landscape is dominated by narrow shelterbelts and tree lined field margins in an intensively managed agricultural and urban landscape. This type of distribution is not uncommon in Britain, and is a main feature of Scottish landscapes in the Central Lowlands and some eastern areas of Scotland.

6.1.4. The remnant semi-natural ancient woodlands of West Lothian have suffered fragmentation, despite some protection in the past within private estates, and more recently by site designation. Over the last 10 years or so it has been realised, that over Britain as a whole, the conservation of biodiversity, in general, is not guaranteed simply by the designation of ecologically important sites. (Hawkins and Selman, 2002) Designated sites remain fragmented and, from a biodiversity perspective, suffer attrition when surrounded by intensive agriculture, urban development and disturbance. Thus landscape ecology has focused on issues of habitat connectivity and minimum patch

size requirements. However, the method of assessing the functional connectivity of a landscape for a species must remain simple. It is difficult to obtain autecological information for species, and virtually impossible to analyse and optimise landscape suitability for several individual species of importance.

6.1.5. All species listed in Table 4.3.1 and others (one may consider- such as the ancient woodland indicator plants) have been classified in terms of their dispersal ability and area requirements (Table 4.2.1). The suitability of the landscapes of West Lothian can then be judged for that species by referring to the FHN analysis from BEETLE described in the results section of the report.

6.1.6. We recommend that native woodland expansion aims to provide at least 150m minimum width corridors to connect woodlands. This recommendation is a judgement based upon the experience of a number of studies described in. (Bennett, 2003) Also work by Watts (unpublished pers. comm.) has shown that woodland patches of 4 ha or more within an intensive agriculture matrix in southern England were more likely to have more than 2 notable woodland specialist plant species, compared to smaller woodland patches. A minimum width of 150m will allow for 2 tree heights (50m) of woodland edge either side of a 50m (2 tree heights) core woodland area corridor. This will provide connectivity for broadleaved woodland dispersal limited specialists, as well as woodland generalists, in the long term.

6.1.7. The analysis showing the effect of the transport infrastructure on mobile woodland generalist networks is exploratory. We have made the assumption that motorways are dispersal barriers and that no individuals will cross. The likelihood is that a proportion of individual land-based species seeking to cross motorways will succeed. The model should really reflect this, but at this time cannot accommodate individual dispersal events or the stochasticity of these events. New developments of BEETLE will incorporate these ideas.

6.1.8. Two final points, which are important considerations when forming plans for landscapes of the future. Firstly, habitat quality has the same importance as its spatial arrangement in the landscape. Although the analysis and results described in this report depend of the quality of the habitat described, no attempt has been made to ground-truth the habitat quality. Secondly, recent work by Ilka Hanski (pers. com.), studying habitat specialist butterfly species in Finland, has shown there can be a considerable time delay for a meta-population to re-equilibrate to the effects of fragmentation and habitat loss. We should be aware of this fact in using records of species occurrence, to show that habitat in recently disturbed landscapes remains suitable.

7. Conclusions and Recommendations

7.1.1. The study has defined three Core Ancient Woodland Areas (CAWA) within West Lothian. In each, there is recent evidence of high woodland biodiversity on the basis of the occurrence of ancient woodland plant indicators.

7.1.2. In developing a Forest Habitat Network strategy for the county, it will be important to secure and expand this habitat, to conserve the biodiversity present. Ancient semi-natural woodland habitat is a present day refugium for

woodland species in the county. It holds the potential with which we can plan for more widespread high quality woodland habitats in the future.

7.1.3. Within each of the CAWA, the generic focal species analysis has shown where to concentrate woodland expansion to build large core woodland areas, and expand new corridors to link high biodiversity patches in the landscape.

7.1.4. Much of the county is suitable for the expansion of lowland mixed broadleaved woodlands. Richer soils on marine clays will be suitable for ash and alder woodlands. Sandier texture soils will be better suited to oak dominant communities. The wetter climate and soils of the upland fringe will be more suited to wet birch woodlands. This can only be a broad recommendation as the site quality is best judged by site survey.

7.1.5. The Local Plan for development intersects a number of key areas where woodland expansion for developing forest habitat networks is essential. For a few of these sites the conflict could be resolved by incorporating woodland into the development plans. However this will only be an effective measure for woodland specialists, if new woodland blocks are of sufficient size (150 m minimum width) to develop core woodland conditions. This will require a minimum of 50 m width for core woodland conditions, surrounded on each side by a minimum 50 m (2 tree heights) of woodland edge habitat. Only if these conditions are met, will suitable habitat for woodland specialists evolve in time.

7.1.6. In some areas, close to ancient woodland remnants, if planned development goes ahead the biodiversity value of the woodland will be damaged. This will happen usually as a result of edge-effects e.g. disturbance from recreation, fly-tipping, removal of deadwood etc. Such development is more concentrated and more likely to further fragment specialist woodland habitats in the Calders CAWA.

7.1.7. Several FHN clusters could be linked across the central and northern parts of the county to link woodland suitable for dispersal limited woodland generalists between the 3 CAWAs. In particular, the woodlands south of Linlithgow form nodes of existing small networks that could be linked between the Avon CAWA and the Hopetoun CAWA. A framework woodland structure currently exists, but needs to be expanded, to link the Hopetoun and Calders CAWA.

7.1.8. New planting should also be concentrated between the conifer plantations to the south and the Calders CAWA. A FHN link between Murieston and Blackhall, and between Addiewell and Woodmuir would help incorporate the large conifer plantations into the woodland biodiversity conservation plan for the county. In time through restructuring and new species, Woodmuir and Camilty plantations could provide a valuable woodland habitat of high biodiversity value.

8. References

Bennett, A.F., 2003. Linkages in the Landscape: the role of corridors and connectivity in wildlife conservation. IUCN, Gland, Switzerland.

Ellenberg, H., 1988. Vegetation ecology of Central Europe. Cambridge University Press, Cambridge.

Forman, R.T.T. and Godrum, M., 1986. Landscape Ecology. John Wiley and sons.

Hawkins, V. and Selman, P., 2002. Landscape scale planning: exploring alternative land use scenarios. Landscape and Urban Planning, 60(4): 211-224.

Humphrey, J. et al., 2003. Balancing upland and woodland strategic priorities, Forest Research.

Lambeck, R.J., 1997. Focal species: a multi-species umbrella for nature conservation. Conservation Biology, 11: 849-856.

Opdam, P., Foppen, R. and Vos, C., 2002. Bridging the gap between ecology and spatial planning in landscape ecology. Landscape Ecology, 16: 767-779.

Opdam, P. and Pouwels, J.V., 2003. Landscape cohesion: an index for the conservation potential of landscapes for biodiversity. Landscape Ecology, 18: 113-126.

Peterken, G.F., 1974. A method of assessing woodland flora for conservation using indicator species. Biological Conservation, 6: 239-245.

Peterken, G.F., 2000. Rebuilding Networks of Forest Habitats in Lowland England. Landscape Research, 25(3): 291-303.

Peterken, G.F., Baldock, D. and Hampson, A., 1995. A Forest Habitat Network for Scotland. Research, Survey and Mointoring Report 44, Scottish Natural Heritage, Edinburgh, Scotland.

Rose, F., 1999. Indicators of ancient woodland. British Wildlife, 4: 241-251.

Smith, D.A. and Hellmund, P.A., 1993. Ecology of Greenways: Design & Function of Linear Conservation Areas. University of Minnesota Press, 238 pp.

Smith, P., Dixon, R.O.D. and Cochrane, M.P., 2002. Plant life of Edinburgh and the Lothians.

Spencer, J., 1990. Indications of antiquity: some observations of the nature of plants associated with ancient woodland. British Wildlife, 2: 90-102.

UNCED, 1992. Earth Summit, United Nations Conference of Environment and Development. The Regency Press, London, Rio de Janeiro.

UNEP, 2003. Item 4.1 of 9th meeting of the subsidiary body on scientific, technical and technological advice, November 2003, Montreal, Canada. United Nations Environment Programme.

Verboom, J., Foppen, R., Chardon, P., Opdam, P. and Luttikhuizen, P., 2001. Introducing the key patch approach for habitat networks with persistent populations: an example for marshland birds. Biological Conservation, 100: 89-101.

Vos, C.C., Verboom, J., Opdam, P.F.M. and Braak, C., 2001. Toward Ecologically Scaled Landscape Indices. The American Naturalist, 157: 24-41.

Watts, K., 2003. Landscape Ecology Programme ROAME, Forest Research.

Wilson, S.M., Pyatt, D.G., Malcolm, D.C. and Connolly, T., 2001. The use of ground vegetation and humus type as indicators of soil nutrient regime for an ecological site classification of British forests. Forest Ecology and Management, 140: 101-116.

Appendix 1 -Definition of habitat

2 GIS layers are used as sources in different geographical regions of the study area.

West Lothian, Edinburgh City, Midlothian : phase 1

Generic focal spp "generalist" habitat :	Phase 1 – all A code polygons SSNWI – all polygons
Generic focal spp "specialist" habitat :	Phase 1 – A.1.1.x; A.1.3.x SSNWI – BL, 80-90% BL, Mixed

Patch size threshold habitat layers were produced by defining habitat layers including only polygons with area over a defined threshold (2ha or 10 ha). These habitat layers were eventually discarded.

Layers of 'interior' habitat were created by defining habitat polygons as those defined by subtracting a 50m buffer zone from the specialist and generalist habitat layers defined above.

All habitat layers rasterized at 10m resolution for BEETLE analyses. Classification was: ZERO for habitat; null (no data) for non-habitat.

Definition of permeability/cost surfaces

3 GIS layers (Ph1, SSNWI, LCM) are used as sources for cost surface layers. The costs are defined in the spreadsheet <.xls>. Tables of habitat codes and dispersal costs are linked to habitat themes to produce polygon cost layers; these are rasterized to give the cost surface elements; the cost surface element are combined as below to give the cost surfaces.

West Lothian, Edinburgh City, Midlothian: phase 1 costs overlay LCM woods
Complement of above: SSNWI costs overlay LCM – woods

Treatment of roads

Roads may be problematic in BEETLE analysis because they are linear rather than two-dimensional features. Their presence may be important to some dispersers and insignificant to others. Where they do provide obstruction to movement it may manifest in terms of a reduced probability of crossing rather than a reduction in dispersal distance.

In these analyses, two schemes are used with respect to roads. In the first, roads are ignored completely. In the second, only motorways and dual carriageways are considered, but they are considered to act as absolute barriers. Selected features of the roads vector layer are rasterized at 10 m resolution to give a roads raster with

roads represented by strings of 10 x 10 m cells. The cost surfaces are then overlaid with the roads layer, where road cells are given a cost of 5000m. Habitat rasters are overlaid with the roads raster so that habitat cells containing roads are reclassified as non-habitat.

Generic species scenarios

So far, BEETLE analyses for scenarios corresponding to three generic focal species have been completed. These are:

a. Dispersal-limited interior broadleaved specialist (insensitive to roads).
b. Dispersal-limited woodland generalist (sensitive to roads).
c. Freely dispersing woodland generalist (sensitive to roads).

No threshold has been set for habitat patch size on the basis that even small areas of habitat may be usable if they are indeed functionally connected to other suitable areas of habitat. Each of the above three 'generic species' could be split into an 'area limited' and 'area indifferent' species on the basis of the quantity of habitat available in each network.