Glasgow and Clyde Valley Integrated Habitat Networks

gcv green network

Forest Research

Cover photographs provided by Scottish Wildlife Trust and Forestry Commission

Glasgow and Clyde Valley Integrated Habitat Networks

Mike Smith, Darren Moseley, Jordan Chetcuti, & Monica de Ioanni

Ecology Division, Forest Research, Northern Research Station, Roslin, Midlothian, EH25 9SY

Contract report to Glasgow & Clyde Valley Green Network Partnership

7th November 2008

Executive Summary

Introduction

The Glasgow and Clyde Valley (GCV) catchment contains a wide of range of diverse habitats and landscapes types. A long history of intensive land-use throughout the GCV has resulted in the loss and fragmentation of semi-natural habitats and a subsequent reduction in biodiversity. Conservation policy and practice now seek to reverse the effects of fragmentation by combining site protection and rehabilitation measures with landscape-scale approaches that improve connectivity and landscape quality,

The 2006 GCV Structure Plan promotes the vision of a Green Network that spans the eight local authority areas which constitute the GCV area. The Integrated Habitat Network (IHN) modelling approach will support this by providing a strategic framework for functioning habitat networks across the GCV focusing on three key habitat types. Habitat networks are a configuration of habitats that allows species to move and disperse through the landscape. The development and application IHN modelling provides a Decision Support Tool that can identify areas that are ecologically connected and can be used to target and justify planning gain and conservation effort in relation to policy drivers.

IHN Modelling

This report describes a detailed desk study using digital data on a geographic information system (GIS) to identify IHNs in the GCV area. The analyses uses a landscape ecology model from the 'BEETLE' (Biological and Environmental Evaluation Tools for Landscape Ecology) suite of tools to assess the spatial position and extent of functional habitat networks.

The BEETLE least-cost focal species approach was chosen to map and analyse the IHNs. Different species have different dispersal abilities and habitat requirements and a limited number of species are selected and used to represent key functions of selected habitats and the array of other species that use them. This approach negates the need to carry out a vast number of individual species analyses, which is particularly important as data regarding species habitat requirements and dispersal through the landscape is lacking.

Forest Research has developed the GIS-based BEETLE which can be used to identify and develop IHNs and which will support the planning process, help prioritise conservation effort, prevent further fragmentation of biodiversity and aid connectivity of semi natural habitats. BEETLE model analysis has been well referenced (Watts *et al.,* 2005) and used in a variety of projects such as developing forest habitat networks across Scotland. The application of IHNs within the GCV will be the first time that the multiple habitat network approach has been used to solicit planning and development programmes in key areas.

The selection of the habitats to be modelled, and the species used to inform the analysis, were identified through a series of expert stakeholder workshops. The model outputs are GIS maps that can be used to assess habitats and how connected they are within their associated networks and within the wider landscape.

Study Objectives

The objectives of the study were to identify:

- Focal species appropriate for the region and to research and describe elements of their autecology and to classify their functional interaction with habitat and the matrix of the wider landscape. These will be determined at a stakeholder workshop, but are likely to be woodland, unimproved grassland and wetlands (fen, marsh & swamp as well as that on peat).
- Key areas for native woodland restoration and expansion in order to link core woodland habitats within the GCV and between neighbouring networks (*e.g.* in the Lothians and Falkirk)
- Key areas for expansion or restoration of a number of identified open ground habitats to link core habitat areas within GCV and between neighbouring areas, to maintain their ecological function and viability, as well as creating a functionally connected network
- The land-use conflicts and the trade-offs required to deliver an integrated habitat network that combines several specific habitat types
- Conflicts and opportunities for habitat networks associated with development proposals, historic landscapes, and landscape character
- The opportunities to enhance and expand the Integrated Habitat Network associated with Local Plan Core Development Areas, and the prescriptions required for development to contribute towards this

Analysis

Habitat network modelling has the potential to support and guide the planning process and to target conservation effort by highlighting areas that prioritise the greatest development potential of habitat protection and enhancement. An analysis of the habitat networks was undertaken on a GCV wide basis to identify potential Priority Enhancement Areas. These are key areas for habitat restoration detailed in the GIS maps were chosen on the basis that they are:

a) the largest encompassing networks;

b) the greatest area of habitat within these networks, and

c) the largest number of the contained habitat networks.

The Priority Enhancement Areas include areas such as the Clyde Valley and Kilpatrick Hills woodlands, the wetlands of the Kelvin and Forth Clyde canal and the unimproved grasslands of Renfrewshire.

The identification of Priority Enhancement Areas will help target effort towards the development of networks for woodlands, wetlands, and grasslands in these areas and will also help link the GCV IHN to neighbouring habitat networks in Falkirk, Loch Lomond and the Trossachs National Park, and Edinburgh and the Lothian's, further highlighting the importance of ecological connectivity throughout Scotland's Central Belt.

In addition to the GCV wide analysis the model was applied to individual sites to demonstrate how optimal solutions can be found which do not negatively affect proposed developments, but which can incorporate strategically located habitats to provide connectivity and enhance the network. This type of analysis will be extremely useful in informing master planning or the development of Community Growth Areas or Corridors.

Key findings

Key findings of the study are:

- The strength of the BEETLE approach lies in taking account of local conservation priorities and making best use of local expertise. Engaging with local stakeholder groups has been vital part of this process and enables the networks to relate to local on-going projects;
- The BEETLE approach could be used to help with the spatial targeting of urban planning, agri-environmental schemes and river basin management plans while also guiding actions for consolidating designated sites;
- LBAPs, Single Outcome Agreements, and SNH Natural Futures provide appropriate scales and mechanisms for determining network priorities and for informing the regional targeting of agri-environment incentives;
- The successful implementation of habitat networks requires the integration of local and national policy conservation priorities and planning mechanisms with network modelling and "on- the-ground" advice and execution; and
- Engaging with local stakeholder groups is a vital part of the process of identifying and developing habitat networks.

Recommendations

Key Recommendations of the study are:

- IHN modelling should become an integral part of local authority decision-making process';
- Priority Enhancement Areas should be used to identify opportunities where effort can be undertaken to strengthen existing habitat networks;
- Delivery of the network requires tech transfer to the biodiversity officers and planners and ways of facilitating this should be explored;
- The integration of activities associated with the Commonwealth Games and links with other regional habitat networks should be considered a priority;
- The manipulation and interpretation of oblique aerial photographs could be of value as a tool for communicating the visual impact of network development at a larger scale and to a wider group of stakeholders and this should be explored;
- The availability of good land cover data is also essential for the modelling. Phase 1 survey information on semi-natural habitats is the main data requirement. It is recommended that Phase 1 be reviewed and supplied in digital format for the whole of the region. Once data has been improved, the changes could be incorporated into the landcover data set and the network analyses re-run;
- Habitat and land cover surveys should be undertaken to update and improve landcover data, particularly for Phase 1 surveys;
- The modelling of "people networks" would add to the planning of a green network approach, enabling targeted improvement of greenspace to achieve multiple objectives. This approach should be explored;
- Methods for monitoring the success of habitat network implementation and development include: assessing habitat condition and ecosystem development;

tracking the distribution and dispersal of both focal and functional species; recording evidence of species use of new habitats and undertaking post-hoc genetic analysis to infer patterns of migration. An evaluation system utilising some or all of the above should be developed;

- Ecosystem development should be monitored to provide feedback on the effectiveness of improvement strategies;
- The IHN process should be used to inform future reviews of the Glasgow and Clyde Valley unitary authorities:
  - Development Plans;
  - Masterplans;
  - Greenspace Strategies; and
  - Biodiversity & Development Supplementary Planning Guidance

The timing of reviews of other plans would enable a review of the IHN / data update to be undertaken to contribute to these reviews;

- Areas of new habitat should be as large as possible and of high quality and structural complexity. The planting of street and ornamental trees will have little impact on improving the biodiversity of the region; and
- The model is updated annually to keep abreast of developments in landscape modelling tools, ecological understanding and land cover information.

Table of Contents

1 Introduction

The project identifies the thematic and locational priorities for habitat restoration through the development of an Integrated Habitat Network (IHN) in the Glasgow and Clyde Valley (GCV) area. IHNs were developed, using the Forest Research Biological and Environmental Evaluation Tools for Landscape Ecology (BEETLE), for a range of habitats and focal species, reflecting local landscapes. These outputs can then be used to prioritise conservation effort.

BEETLE - Biological and Environmental Evaluation Tools for Landscape Ecology

The development of habitat networks is widely seen as a key mechanism for reversing the effects of fragmentation on biodiversity while delivering a range of other social and environmental benefits, such as enhancement of local landscape character and greater opportunities for public access and recreational use. Tools to address habitat fragmentation have evolved from landscape ecology principles examining the metapopulation theory, landscape metrics (e.g. FRAGSTATS – McGarigal et al., 2002) and focal species modelling (e.g. LARCH – Bruinderink et al., 2003; BEETLE – Watts et al., 2005). Application of these principles has enabled assessment of network connectivity and identified opportunities for action at national, regional, and local scales. There is growing interest in applying the concepts to planning and management of rural, peri-urban and urban areas.

The BEETLE network analysis model developed by Forest Research is well documented (Watts et al., 2005) and has been used to determine the habitat network extent and distribution in the Scottish Borders, West Lothian, Edinburgh & the Lothians, Wales, and now across the whole of Scotland (see www.forestresearch.gov.uk/habitatnetworks). The analyses have been developed with, and found favour from, a range of stakeholders across a variety of settings. A study of Lowland Habitat Networks (Humphrey et al., 2005; 2007) has been undertaken to consider the potential for developing networks of non-wooded agricultural habitats and to look at ways of integrating these with forest habitat networks in different landscape settings. Assessments of forest habitat networks (FHNs) are being used to advise funding, e.g. Woodlands In and Around Towns initiative (WIAT) http://www.forestry.gov.uk/forestry/infd-5w2nfz, determine the spatial extent of Atlantic Oakwood networks (Moseley et al., 2006), spatially direct new planting proposals (Moseley et al., 2007), and focus attention of Local Biodiversity Action Plans. Attention is increasingly turning towards the peri-urban and urban environment, consistent with recent Scottish Executive policy. Networks describing ecosystem functionality across urban and rural environments have been identified (Ray et al., 2004; Ray & Moseley, 2006) and Forest Research are now proposing options for an integrated habitat network approach for Glasgow and the Clyde Valley.

2. Objectives

The project work programme focused on the following objectives to identify:

- Focal species appropriate for the region, and to research and describe elements of their autecology to classify their functional interaction with habitat and the matrix of the wider landscape. These will be determined at a stakeholder workshop, but are likely to be woodland, unimproved grassland, wetland (fen, marsh & swamp), and raised/intermediate bog. Elements of the focal species autecology will be researched and described to classify their functional interaction with habitat and the matrix of the wider landscape

- Key areas for native woodland restoration and expansion in order to link core woodland habitats within the GCV and between neighbouring networks (e.g. in the Lothians and Falkirk)

- Key areas for expansion or restoration of a number of identified open ground habitats to link core habitat areas within the GCV and between neighbouring areas, to maintain their ecological function and viability, as well as creating a functionally connected network

- The land-use conflicts and the trade-offs required to deliver an integrated habitat network that combines several specific habitat types

- Conflicts and opportunities for habitat networks associated with development proposals, historic landscapes, and landscape character

- The opportunities to enhance and expand the Integrated Habitat Network associated with Local Plan Core Development Areas, and the prescriptions required for development to contribute towards this

3. A modelling approach to develop Integrated Habitat Networks

3.1 Study area

The study area for this work was defined by the eight GCV Unitary Authority boundaries, with a 5km buffer used to demonstrate where networks extend out to into other Unitary Authorities (Figure 1).

Figure 1– Study area for the GCV Integrated Habitat Network

3.2 The modelling approach

The approach is based on a GIS-based model from 'BEETLE' developed by Forest Research (see www.forestresearch.gov.uk/habitatnetworks). The model considers how areas of habitat are spatially aligned within the whole landscape, and how species can utilise and disperse between patches of habitat. Part of this model is a focal species tool that utilises habitat area requirements and dispersal characteristics to identify functional habitat networks for a given species.

The BEETLE focal species approach was chosen to map and analyse the integrated habitat networks. This approach negates the need to carry out a vast number of individual species analyses, which is particularly important as data regarding species habitat requirements and dispersal through greenspace is lacking. Species which can populate the habitat types were then associated in relation to their particular requirements.

> **Focal Species**
>
> A focal species can be simply defined as 'the species being focused on to examine a particular issue'. A more detailed definition evaluates landscapes in relation to the requirements of all the species present (Lambeck, 1997), focusing on the key issues of habitat requirements and dispersal capability to identify species with the strictest requirements.

3.3 Preparation of geo-referenced data including focal species autecology

3.3.1 Stakeholder Workshop

A Stakeholder workshop was held at the start of the project to help identify priorities and conservation concerns across the area, secure buy-in to the concept and to identify the most important species and habitats for use in the BEETLE modelling to develop an integrated habitat network (IHN) for the GCV. Stakeholders included representatives from Farm Woodland Advisory Group (FWAG), Central Scotland Forest Trust (CFST), Scottish Natural Heritage (SNH), Scottish Environmental Protection Agency (SEPA, and Forestry Commission Scotland (FCS). The discussions identified the following habitats for the modelling process:

- Unimproved grassland
- Floodplain management wetlands
- Woodland Habitats using different woodland types
- Raised/intermediate bog

A full report of the stakeholder workshop can be found in Appendix 2

3.3.2 Focal species autecology

Focal species represent the ecological requirements of a range of species within a particular habitat. The focal species approach is useful in evaluating the impacts of landscape management on biodiversity because it circumvents the need to measure impacts on all species, which would be impractical. A number of studies have used focal species modelling as a way of helping to inform guidelines for habitat creation, restoration and configuration at the landscape scale (e.g. Freudenberger and Brooker, 2004; Humphrey et al., 2007). Usually focal species are selected because they have wider appeal or are of conservation importance in their own right (Fleishman et al., 2000).

The processes involved in focal species selection depend on the objectives of the modelling process (Figure 2). These objectives can focus on either the conservation of existing known biodiversity or on the development of ecological potential, though these are in no way mutually exclusive. The selection of focal species needs to consider scale; developing ecological connectivity across a large region such as the GCV with a wide range of habitats and species is more complex than the restoration of a particular habitat on a nature reserve.

Within these processes, two different approaches were considered, ‘expert decision’ and a ‘species brigading’ exercise, both of which require an element of expert opinion and have a choice between the use of specific or generic focal species. The steps involved in these approaches are set out in Figure 3.

> A **Generic Focal Species** is a conceptual or virtual species, whose profile consists of a set of ecological requirements reflecting likely needs of real species where species data are unavailable. Generic Focal Species are selected to represent particular species, groups of species, habitats, important landscape features or specific policy objectives.

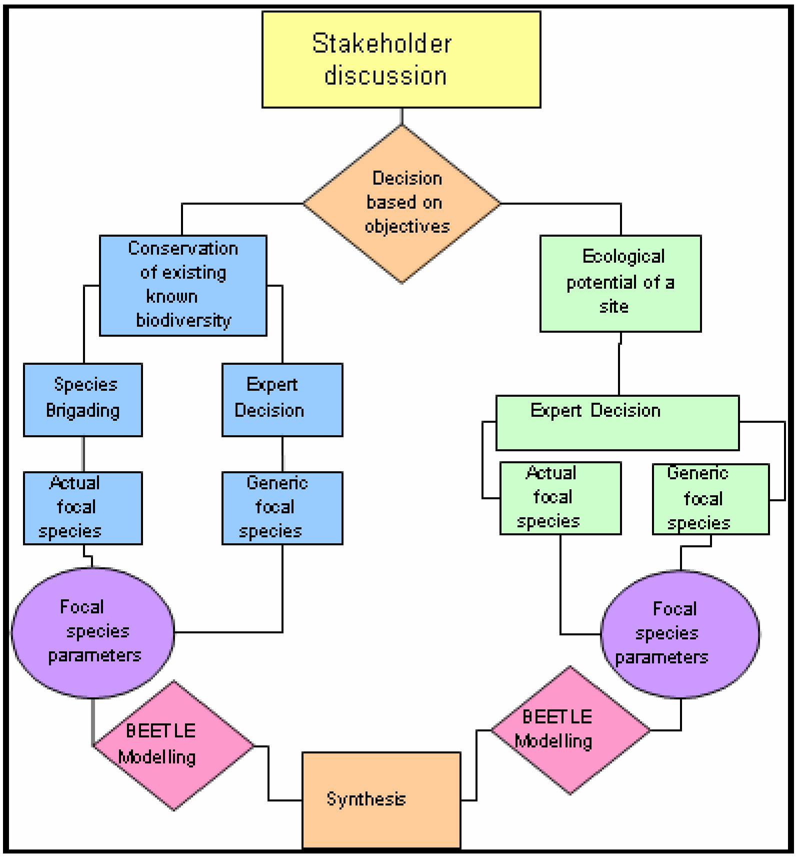
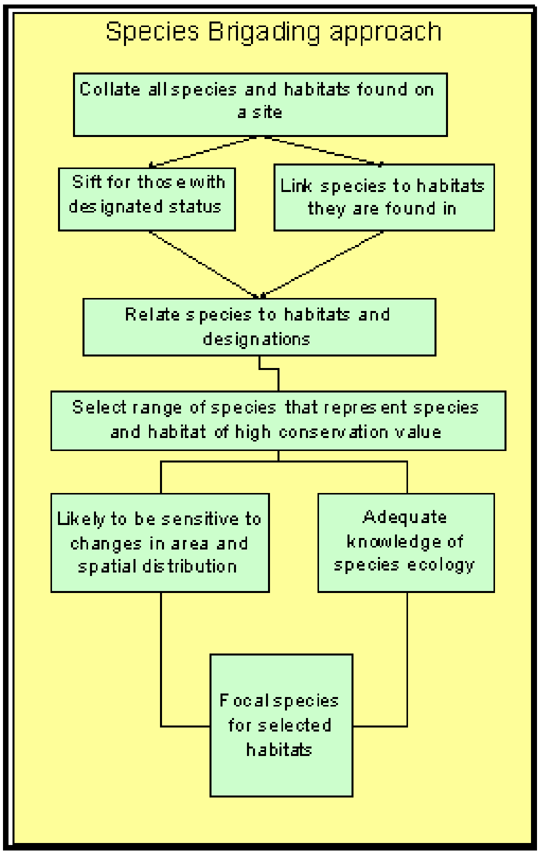


Figure 2 – Focal species flow chart



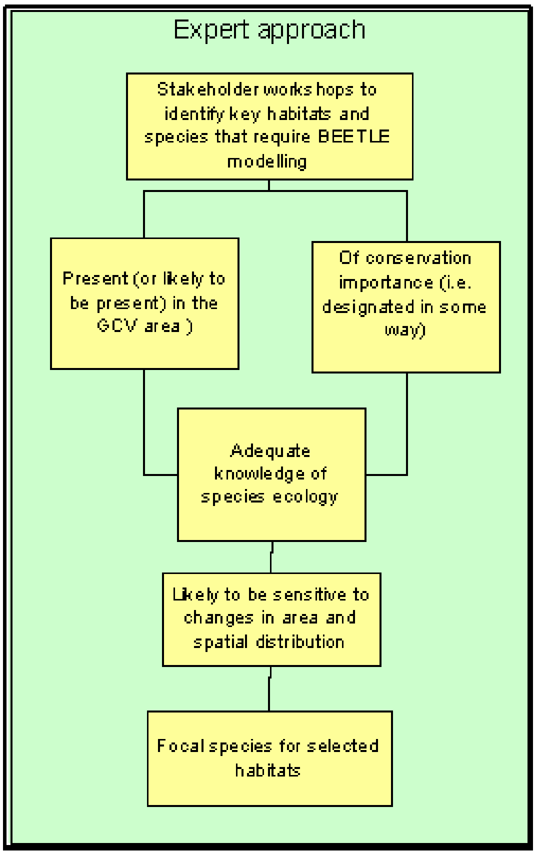


Figure 3 – Focal species selection

There is a degree of subjectivity in both approaches when choosing focal species. The identification of key habitats and species by stakeholders will be dependent on the composition of the stakeholder group and the allocation of species to habitat will involve some subjectivity as some species use more than one habitat. The expert focal species approach uses expert opinion throughout whereas the species brigading is a more structured justification of focal species selection. The brigading exercise identifies species that have been recorded on a site with designations, which have the obligation to be conserved through law. It is dependent however on whether survey work has been undertaken, which in itself, can be subjective and may lead to management decision making being based on survey work on specialist groups of species. The selection of focal species for the GCV area incorporated elements of both approaches. The species brigading exercise was used to back up and refine some of the decisions that arose out of the stakeholder workshops. The selection of the focal species also needs to be based on the criteria below:

1. <u>Presence within the study area</u>

Species were only selected as a focal species if they are known to occur in the study area, or have been recorded there in the past. This process is undertaken in detail through the species brigading exercise.

2. <u>Adequate knowledge of species ecology</u>

The ecology of some of the species groups recorded in the study area is well known (e.g. hoverflies) whereas others have been little studied (e.g. beetles, lichens). Species were only selected where ecological information was reasonable and there was expert knowledge and literature available for consultation. Values for habitat requirements and dispersal distances are required to undertake the BEETLE modelling.

3. <u>Sensitivity to changes in area and spatial distribution of different types of habitats</u>

Figure 4 illustrates how habitat fragmentation has differential impacts on a species' persistence in the landscape, depending on its dispersal ability and habitat area requirements. Species with moderate area requirements and moderate dispersal abilities tend to be more sensitive to fragmentation, and hence to population decline and extinction (towards the left of the diagram).

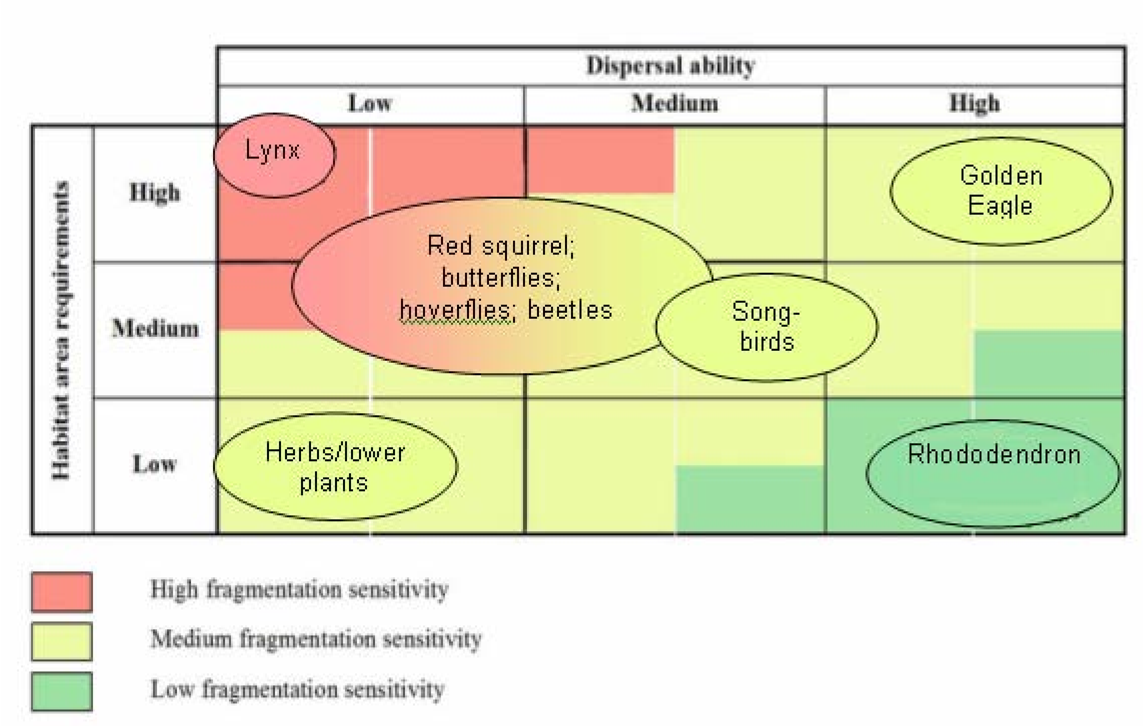


Figure 4 – Examples of the relative sensitivity of species to fragmentation

Equally these are the species that may respond positively to measures to increase connectivity (Figure 4). Species with very poor dispersal abilities (bottom left) are unlikely to respond very quickly, if at all, to reversal of fragmentation and require action that focuses on securing long term survival of existing habitat patches (Figure 5).

For the GCV IHN, species were selected that would be sensitive to changes in the amount and spatial distribution of the key habitat types listed above, and likely to respond relatively quickly (e.g. 50 years) to measures to improve habitat connectivity.

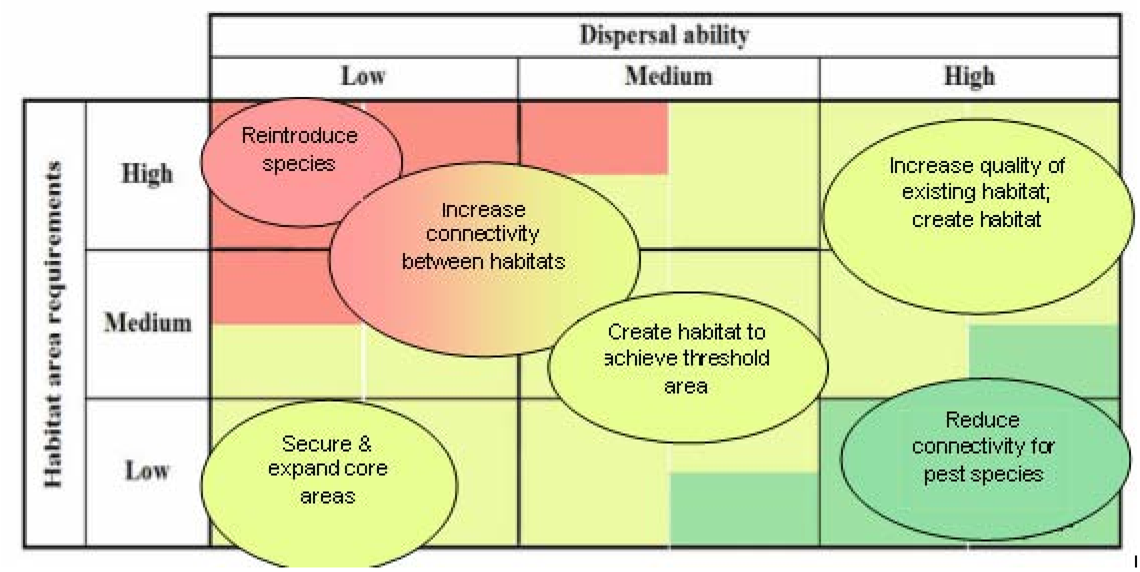


Figure 5 – Management actions based on focal species ecology

4. <u>Conservation Importance</u>

Species were also selected if they had one or more of the following designations

- UK BAP Species,
- Wildlife & Countryside Act (W & CA) Schedule 8 species,
- EC Habitats and Species Directive Annex1 species;
- IUCN Red Data Book (RDB) species
- SNH priority species

A list of species of conservation concern was drawn up to identify appropriate focal species that are representative of the identified priority habitats. This was carried out through a literature search, discussions with appropriate species experts, and the involvement in a stakeholder workshop to guide the process. Surrogate species were employed where autecological data was scant or if species from the local list did not span the spectrum of sensitivity to landscape fragmentation.

The species brigading exercise was intended to relate those species recorded in the GCV to their designations, using their conservation status and habitat type. This allows planners to understand any legal or corporate obligations that they may have for the protection of species or habitats within the GCV area. This can then be used as part of the decision making process for the focal species selection.

The first step in this process was to collate all datasets using available records in NBN gateway. A parallel process collated all databases of designated species to identify those species with a designation. These databases were then formatted to allow interrogation, enabling marshalling of the species, habitat and designation data in relation to one another (Table 1 and Table 2).

Table 1 – All species recorded in GCV area with conservation status

	Status									
Category	**B**	**R**	**Na**	**Native**	**Nb**	**RDB**	**Sch. 8**	**UKBAP**	**Common Species**	**Total Species**
Amphibian							2	2	1	5
Birds								12	38	50
Bryophyte	3								66	69
Fish	1							4	12	17
Fungi									50	50
Invertebrate	1	1	5	1	39	9		3	1160	1218
Lichen								1	1	2
Mammal								8	21	29
Reptile								2	1	3
Vascular plant	7							1	101	109
Total	12	1	5	1	39	9	2	33	1451	1553

Explanation of codes:

B = breeding
R = restricted or rare
Na = nationally notable and have been recorded in 16-30 ten kilometres squares in UK;
Native = native
Nb = nationally notable and have been recorded in 31-100 ten kilometres squares in UK;
RDB = red data book listed; RDB 3= rare, RDB K = insufficiently known

Sch. 5 = Schedules of the Wildlife & Countryside Act 1981 with respect to sale only
UKBAP = listed in UK Steering Group response to Biodiversity, the UK Action Plan, as priority species

Main data sources:

- Butterfly Conservation Records - Moths Species records and status specification for Moths in Clyde Valley. VC76 (Renfrewshire and Inverclyde), VC77 (Lanarkshire) and VC86 (Dunbartonshire).
- NBN data base Clyde Valley Woodlands (NNR, National Nature Reserves)
- NBN data base Clyde Valley Woodlands (SAC, Special area of Conservation)
- http://www.clydevalleywoods.org.uk/cvw/europe.htm
- UK Biodiversity Action Plan http://www.ukbap.org.uk/
- Status List designation www.jncc.gov.uk

The next step was to determine the dispersal abilities and minimum area requirements for each species were assessed through a review of autecological accounts (Table 2 and Table 3).

Table 2 – Designated Species in Glasgow and Clyde Valley

Category	Woodland	Wetland	Grassland
Amphibian	2	3	
Bird	15		
Fish		5	1
Invert	4		
Lichen	1		
Mammal	3	3	
Plant	6	1	1
Reptile	2		
Total Species	33	12	2

Associated habitat for all species in the table are: grassland, wasteland, heath, bog, raised bogs, upland blanket bogs and moorland. Within the GCV butterfly records, data of species-specific dispersal ability had not been reported, results were refer to the family group of butterfly.

Table 3 – Butterfly species and dispersal ability

<table>
<tr><th rowspan="2">Familia</th><th colspan="2">Dispersal (Km)</th></tr>
<tr><th>Mean</th><th>Maximum</th></tr>
<tr><td>Family Lycaneidae</td><td rowspan="2">0.05 and 0.25</td><td rowspan="2">1.4 and 5</td></tr>
<tr><td>Lycaena phlaeas
Polyommatus icarus</td></tr>
<tr><td>Family Nymphalidae</td><td rowspan="2">0.57</td><td rowspan="2">1.7</td></tr>
<tr><td>Vanessa atalanta
Vanessa cardui
Aglais urticae
Inachis io
Aphantopus hyperantus
Coenonympha pamphilus
Coenonympha tullia</td></tr>
</table>

The dispersal abilities of species in Table 4formed the basis of selecting the dispersal distances within the modelling process for the different habitat they represent.

Table 4 – Ecological profiles of focal species used in the GCVIHN analysis

Species	Mean dispersal Km	Maximum dispersal Km	Category	Habitat
Triturus cristatus	0.02	0.15	Amphibian	Wetland
Coenonympha tullia	0.5	2.0	Insect	Heath, raised bogs, upland blanket bogs and moorland
Sympetrum danae		1.75	Insect	Peatland, wetland, Bog
Lycaena phlaeas	0.05	1.4	Insect	Grassland, wasteland, heath, bog
Polyommatus icarus	0.25	5.0	Insect	Grassland, heat sand dunes
Vanessa atalanta	0.5	2.0	Insect	Woodlands, heath, moors and bog, coastal, riverbanks
Vanessa cardui	0.5	2.0	Insect	Woodlands, heath and moors, bog
Aglais urticae	0.5	2.0	Insect	Woodlands, heath/moors, bog
Inachis io	0.5	2.0	Insect	Woodlands, heath/moors, bog
Aphantopus hyperantus	0.5	2.0	Insect	Woodlands, heath/moors, bog
Coenonympha pamphilus	0.5	2.0	Insect	Woodlands, heath/moors, bog
Epirrita filigrammaria	0.4	2.0	Insect	Heath, Blanket Bog
Anarta myrtilli	0.4	2.0	Insect	Heath, bog
Lutra lutra	4.22	11.46	Mammal	Freshwater
Mustela putorius	2.29	5.16	Mammal	Woodland and river banks
Lepus timidus	2.0	5.5	Mammal	Pine plantations
Arvicola terrestris	1.0	2.0	Mammal	Freshwater
Erinaceus europaeus	0.88	3.02	Mammal	Woodland, grassland and urban
Lepus europaeus	0.58	2.8	Mammal	Grassland/Woodland
Mercurialis perennis	0.14	0.84	Plant	Woodland
Geum rivale	0.1	1.0	Plant	Unimproved Grassland

3.4 BEETLE analysis

The identification of key areas for habitat restoration and expansion required to link core areas of habitats within and with out the region were undertaken using Forest Research's BEETLE landscape ecology tool. This used the focal species identified in Section 3.3 with a GCV land cover data set assembled from a range of spatial data sets (Table 5) to assess functional connectivity.

Table 5 – Description of land cover datasets used in the project – reproduced in part from Humphrey et al. (2005)

Data	Description	Value
Ordnance Survey® Pan-Government product portfolio	Products include: 1) for large scale mapping - OS MasterMap; Land-Line; 1:10 000 Scale Raster; 2) for small scale mapping – 1:50 000 Scale Colour Raster; 1:50 000 Scale Gazetteer; 1:250 000 Scale Colour Raster; Strategi®; Meridian 2	MasterMap is the definitive, large-scale digital map of Great Britain, containing information on roads, tracks, paths etc. Gives accurate representation of woodland areas and boundaries and can identify linear features which can act as barriers to dispersal or as corridors
Phase 1 Habitat Survey	Broad scale field mapping approach giving information on the extent and distribution of natural and semi-natural habitats	Ideal source of good quality habitat information, but limited in coverage to specific regions. Often only in paper format.
Land Cover Scotland 1988 (LCS88)	Remote sensed dataset derived from aerial photography taken in 1988; provides broad habitat definitions at 1:25 000 scale	Covers the whole of Scotland focusing on semi-natural habitats, is out of date, but currently being updated ("New Image of Scotland")
Land Cover Map 2000 (LCM)	Satellite derived remote-sensed datasets providing broad habitat definitions	Covers the whole of Scotland, but there are problems with accuracy in mapping some upland habitat types
Unitary Authority boundaries	Locations of Local Authority areas	Establishes link between network modelling, local authority areas and LBAPs
Local Plan constraints (settlement areas & proposed housing and industrial areas), and additional new woodland polygons.	Locations of proposed areas of development	Identifies areas in which development are planned, which can be incorporated into scenario development.
SNH BAP priority habitat report and maps	Maps and description of UK BAP priority habitats summary of all previous phase 1 and phase II survey information in Scotland	Provides information on location of key habitats in Scotland
SAC, SPA, NNR and SSSI boundaries	Boundaries of protected areas/sites	Give indication of areas of high conservation value in general
National Inventory of Woodlands and Trees (NIWT)	Derived from LCS88 dataset plus updated to 1995 from FC sources; provides information on broadleaved/conifer woodland > 2ha and small woods and trees (0.1-2ha)	Baseline data source on woodland for Scotland

Table 5 – cont…..

Data	Description	Value
Scottish Forestry Grant Scheme and Woodland Grant Schemes	Regularly updated records of new planting	Gives composition and extent of new woodland areas which can give indication of habitat value
Scottish Semi-Natural Woodland Inventory (SSNWI)	Constructed over the period 1995-2001 using interpretation of aerial photographs taken in 1988. Map of all woodlands > 0.1 ha classified according to degree of semi-natural character	Identifies all semi-natural woodland, useful when combined with NIWT to locate sites of high conservation importance
Scottish Ancient woodland Inventory (AWI)	Map of all ancient (existing since 1750) woodlands over 2 ha in size	Identifies areas of key importance for woodland biodiversity
National Vegetation Classification survey data	Various surveys covering SACs, SSSIs and other habitats of high conservation value in Scotland	Coverage is geographically limited and information can be too detailed to make meaningful links with species requirements
Scottish Integrated Agricultural Control System (SIACS)	Contains information on field sizes and crop types for very field in Scotland	Shape files and data available for individual holdings

Appropriate landcover types were defined as habitat for each of the analyses.

1. Unimproved grassland was defined as Phase1 categories unimproved neutral grassland and marshy grassland.
2. Wetland was defined as all wetland habitats identified in the wetland and grassland NVC survey ranging from small open water bodies to wet woodlands. Great Crested Newts have been identified within the GCV area LBAP's and are a suitable surrogate for wider wetland biodiversity. Improving connectivity for this species would greatly benefit the habitats for a wide range of other wetland species, many of which are of conservation concern within the GCV area.
3. Woodland was defined as all areas of woodland from the MasterMap and Phase1 categories, with broadleaved woodland (including ancient broadleaved woodlands) being identified as a separate group.

These datasets are 'stitched' together to form a dataset which creates a hierarchical landcover of the GCV area with the most relevant habitat information on top. This is then scored to reflect the permeability of the landscape for the focal species that represent the different habitats.

4. Interpretation and applications of the networks

The network outputs constitute part of the decision-making system for strategies designed to reduce the impacts of habitat fragmentation and improve habitat connectivity and biodiversity. The interpretation and suggestions for the application of these outputs are part of this process but need to be implemented in conjunction with sound judgement, based on ecological principles.

The criteria for identifying prime sites for habitat restoration and expansion for GCV were developed and tested through identification of the most valuable core areas of habitat, particularly identified priority habitats.

For each habitat network, the following tasks were undertaken:

1. Identification of priority habitat networks & development of IHNs
2. Use of BEETLE to assess functional connectivity improvements over current situation arising from IHN development scenarios
3. Interpretation of connectivity maps to identify key areas where habitat restoration, creation or expansion could significantly improve functional connectivity
4. An easy to interpret description of the landscape consequences of the habitat expansion scenarios, including the area of habitat and indices of connectivity

Habitat networks were calculated separately for each of the 8 Generic Focal Species and for 2 dispersal distances of: 500 m and 2 km. The dispersal distances have been derived from the autecological assessment, with the smaller distance representing a mean dispersal, and 2 km representing the maximum. By overlaying the 500m network onto the 2 km network we can examine the extent of dispersal overlap of larger networks surrounding the smaller dispersal networks. This allows an assessment of the degree of permeability of the matrix (land cover types not classed as habitat) surrounding a generalist network.

4.1 Woodland networks

The Scottish Forestry Strategy includes an aspiration to increase woodland cover in Scotland to 25% by 2050, requiring the creation of 10,000 ha of new woodlands per year (Forestry Commission Scotland climate change action plan draft for consultation). Although some of this can be achieved through the National Forest Estate, it is likely that much of the new woodland creation will occur on private land. Grants to support this expansion are likely to be accessed through Rural Development Contracts (RDCs), based on a scoring system linked to the proximity or inclusion within existing networks, as discussed in the Regional Project Assessment Committee (RPAC) process. The habitat networks can be used to inform this process by prioritising those applications that contribute towards the development of integrated habitat networks, rather than using a spatially unconstrained approach.

Priority Enhancement Areas (Figure 6) were identified from further analysis of the derived habitat networks to create larger areas that are likely to be priority areas in terms of habitat restoration. Key areas were identified by selecting those with;

a) the largest encompassing networks,

b) the greatest area of habitat within these networks, and

c) the largest number of the contained habitat networks (Figure 7).

This was undertaken to help the prioritisation of conservation effort.

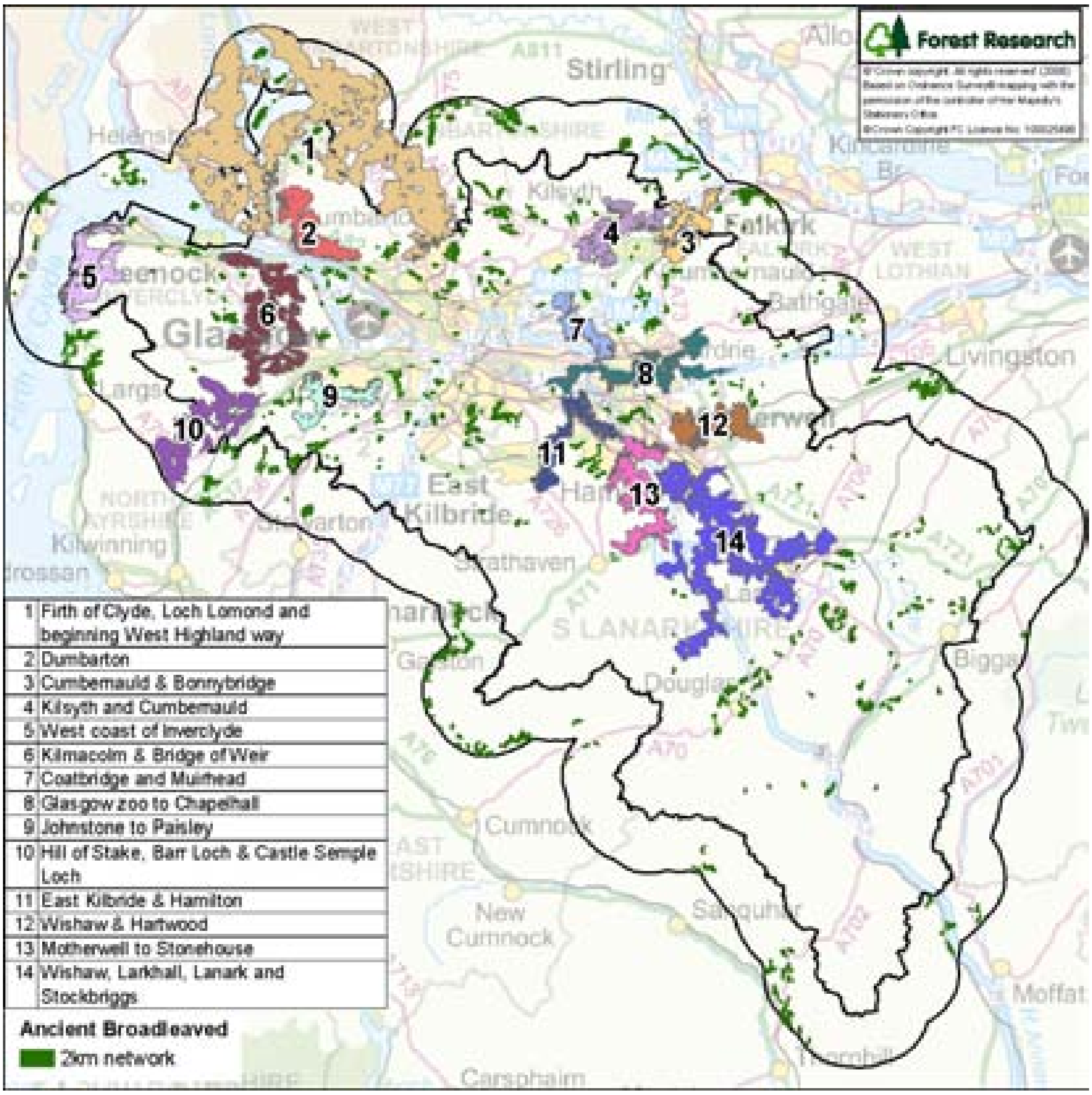


Figure 6 – Priority enhancement areas (each shown in a different colour) for woodlands within GCV.

Woodland network metrics

Woodland generalist

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	10,620	112,425	10.6	6 154
2km	3,194	185,779	58.2	12,745

Broadleaved specialist

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	9,387	30,722	3.3	470
2km	3,737	76,176	20.4	2 893

Ancient broadleaved specialist

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	1,466	12,517	8.5	240
2km	693	29,094	42.0	2,133

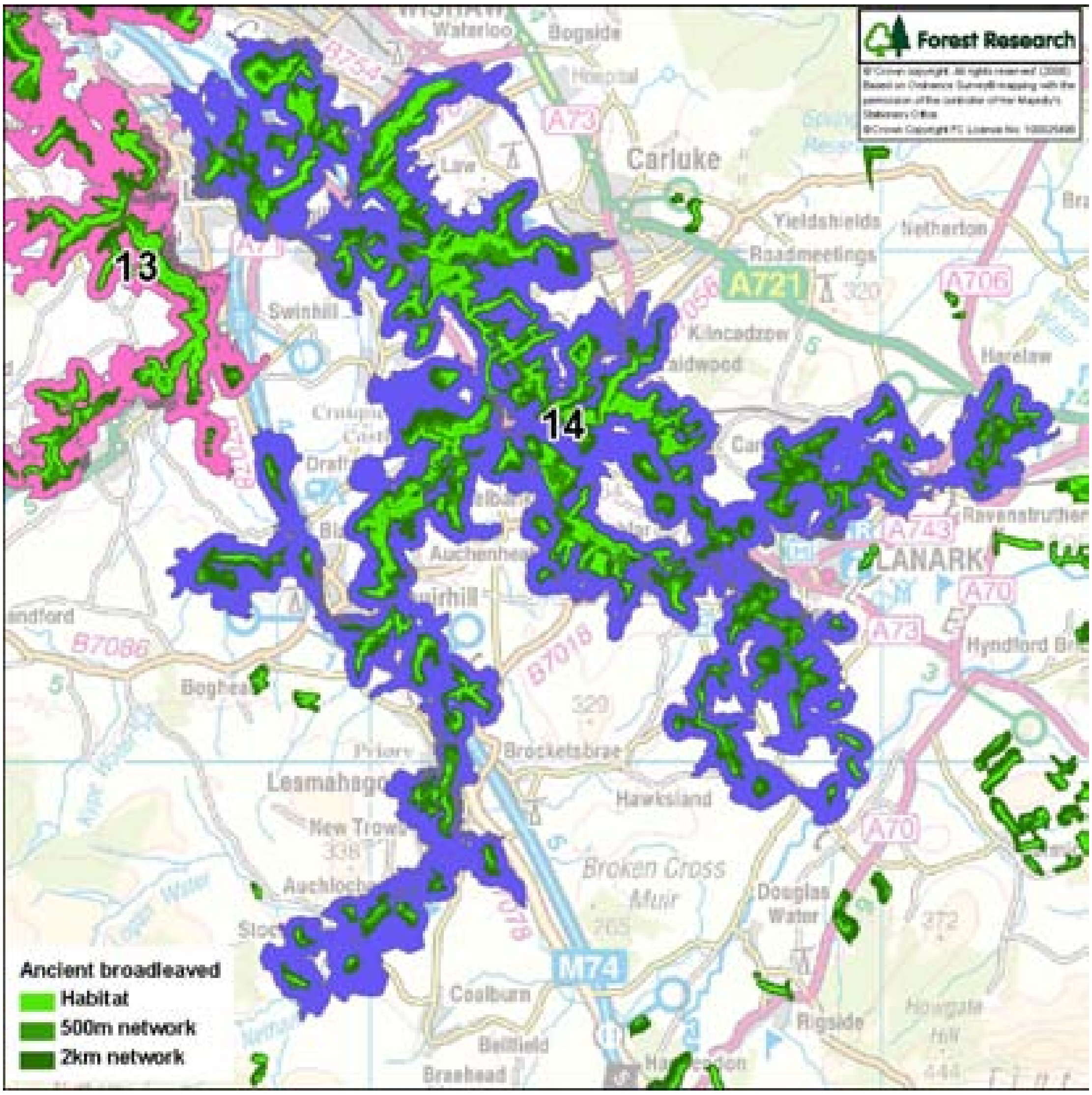


Figure 7 – Detail of a Priority Enhancement Area (each shown in a different colour) and its contained habitat networks

Network development should be initially guided by Priority Enhancement Areas and then by the prioritisation of the following management principles (highest priority first):

- **Protect** and **manage** high quality habitat
- **Restore** and **improve** sites with restoration potential
- **Improve** and **manage** other sites
- **Improve** the **landscape matrix** by reducing land use intensity
- **Create/recreate new habitat** and semi-natural habitat

The following figures demonstrate the effect of targeting the high quality habitat (ancient broadleaved woodland) for enhancement and expansion to provide larger and more robust networks. Figure *8* shows the existing ancient broadleaved, broadleaved and woodland generalist woodlands. Figure 9 shows the broadleaved woodland within Ancient broadleaved networks, this area should be enhanced making these woodlands into high quality habitat (effectively ancient broadleaved woodland, Figure 10) to improve the overall connectivity. This process should be further applied to converting woodland generalist woodlands within these networks (Figure 11) to broadleaved woodland (Figure 12). Figure 13 shows the overall improvements of this first stage of improvements. Mixed or conifer woodland may, where appropriate, be modified to create a more natural structure and composition

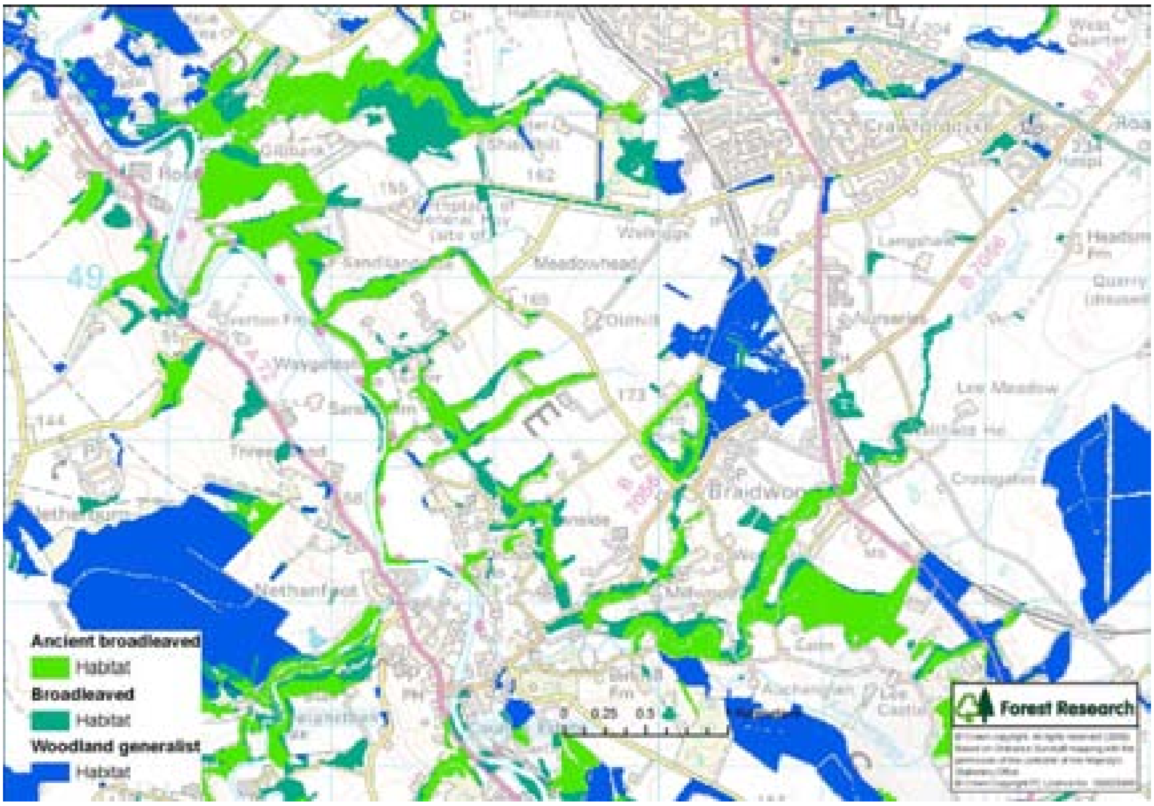


Figure 8 – Existing ancient broadleaved, broadleaved and woodland generalist woodland networks.

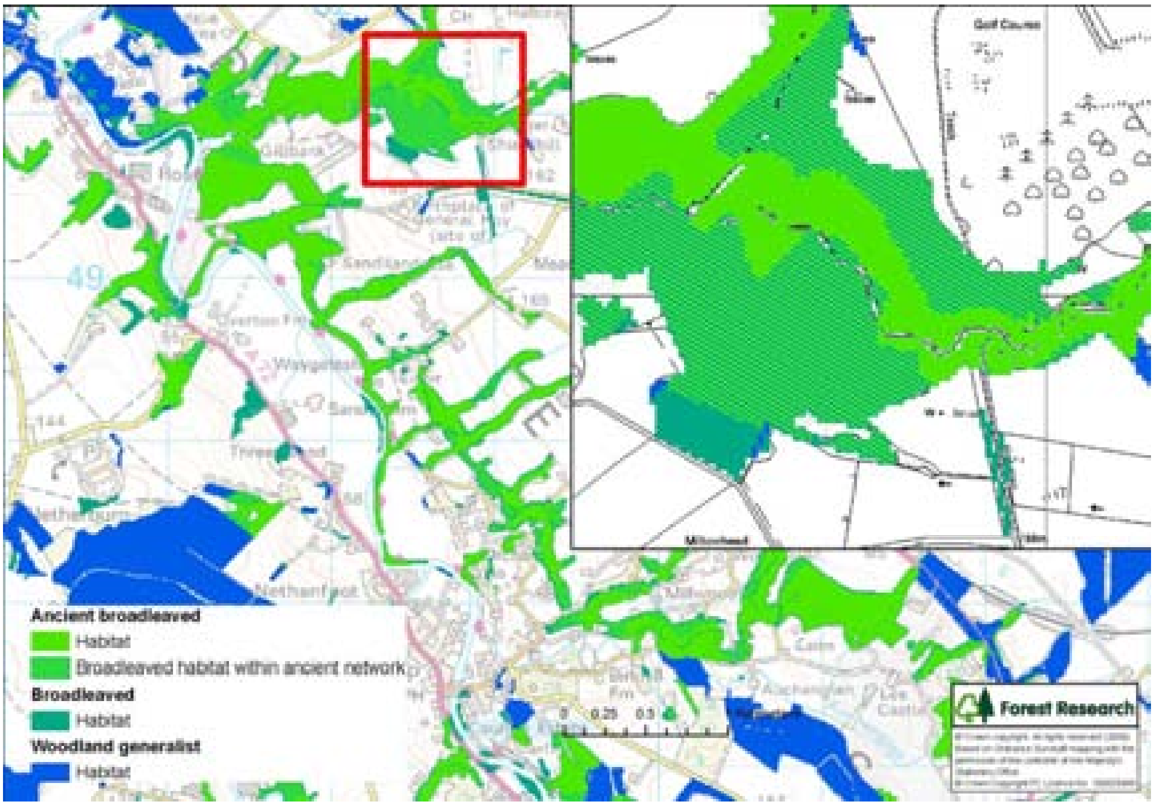


Figure 9 – Broadleaved habitat intersecting ancient broadleaved network.

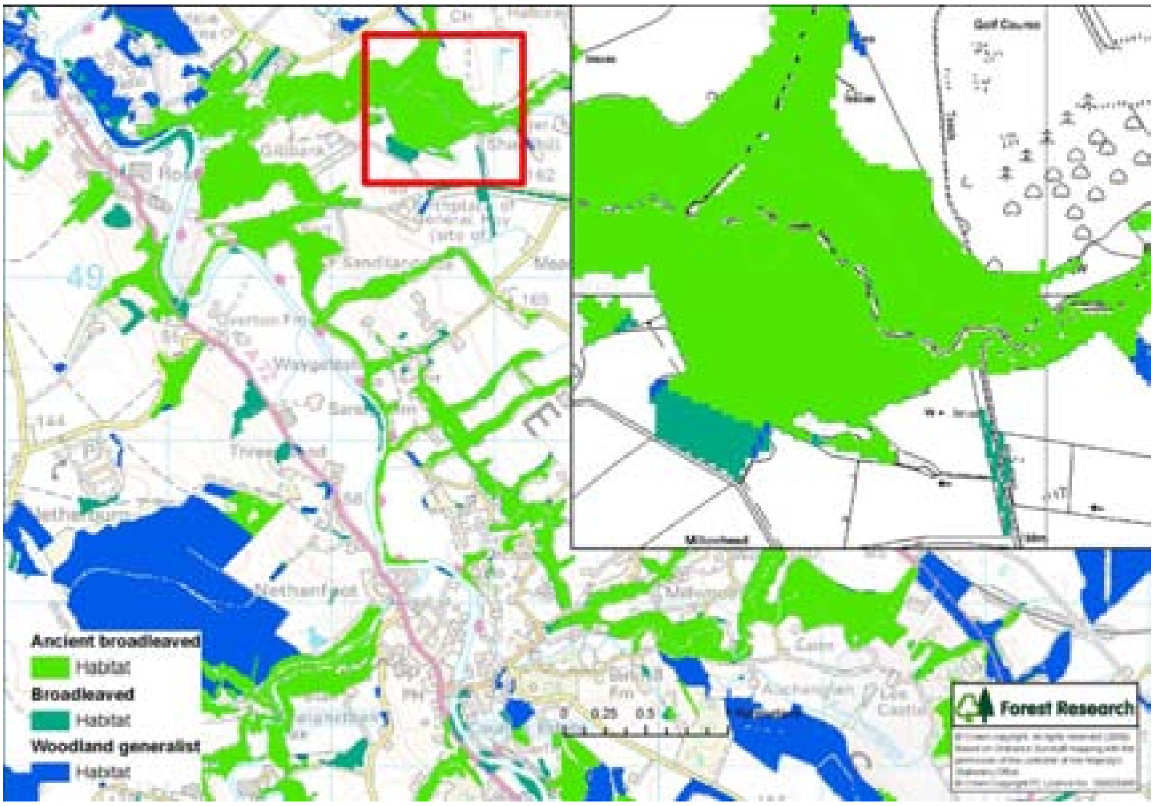


Figure 10 – Converted broadleaved woodland to high quality habitat (ancient broadleaved woodland)

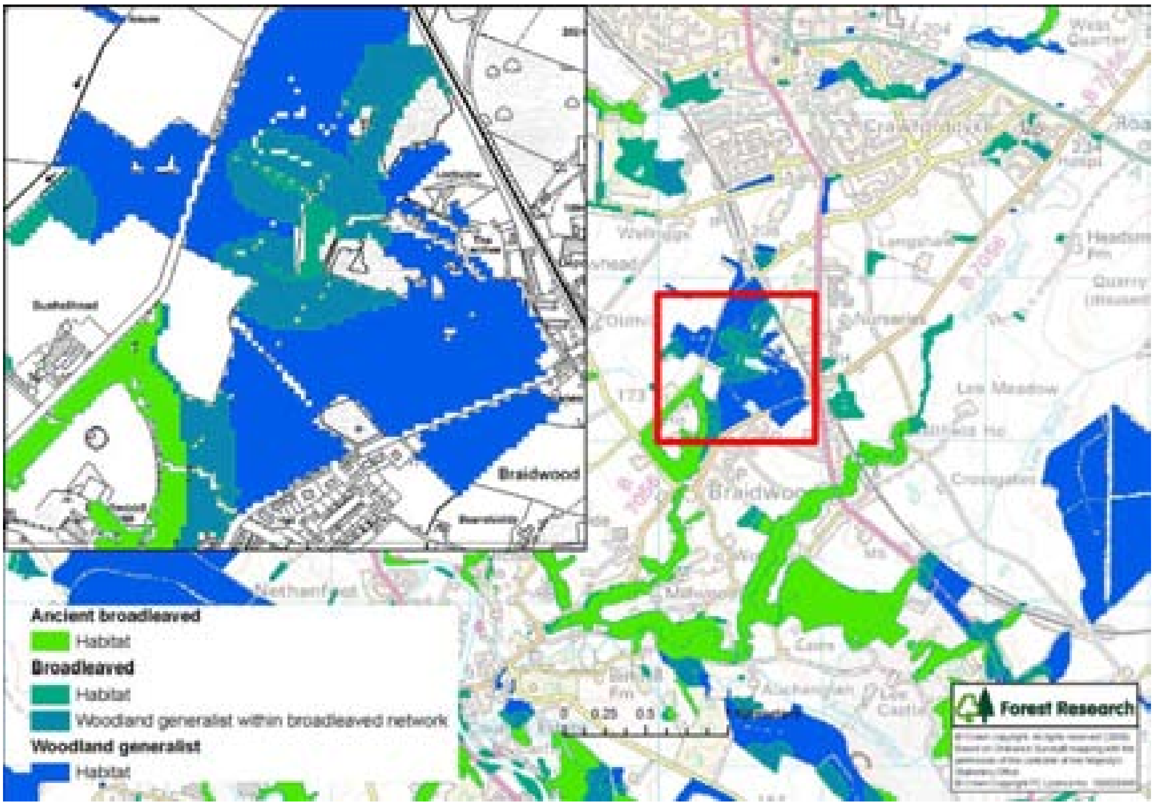


Figure 11 – Woodland generalist habitat intersecting broadleaved.

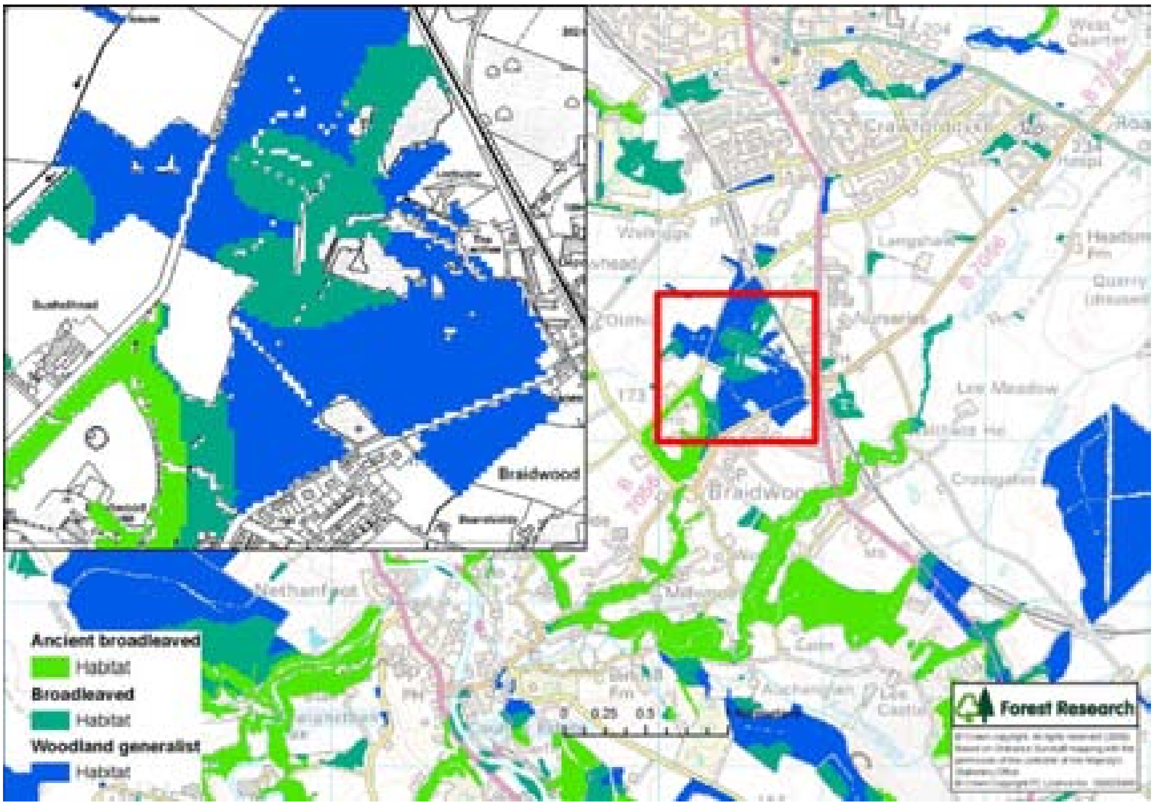


Figure 12 – Converted woodland generalist woodland to broadleaved woodland.

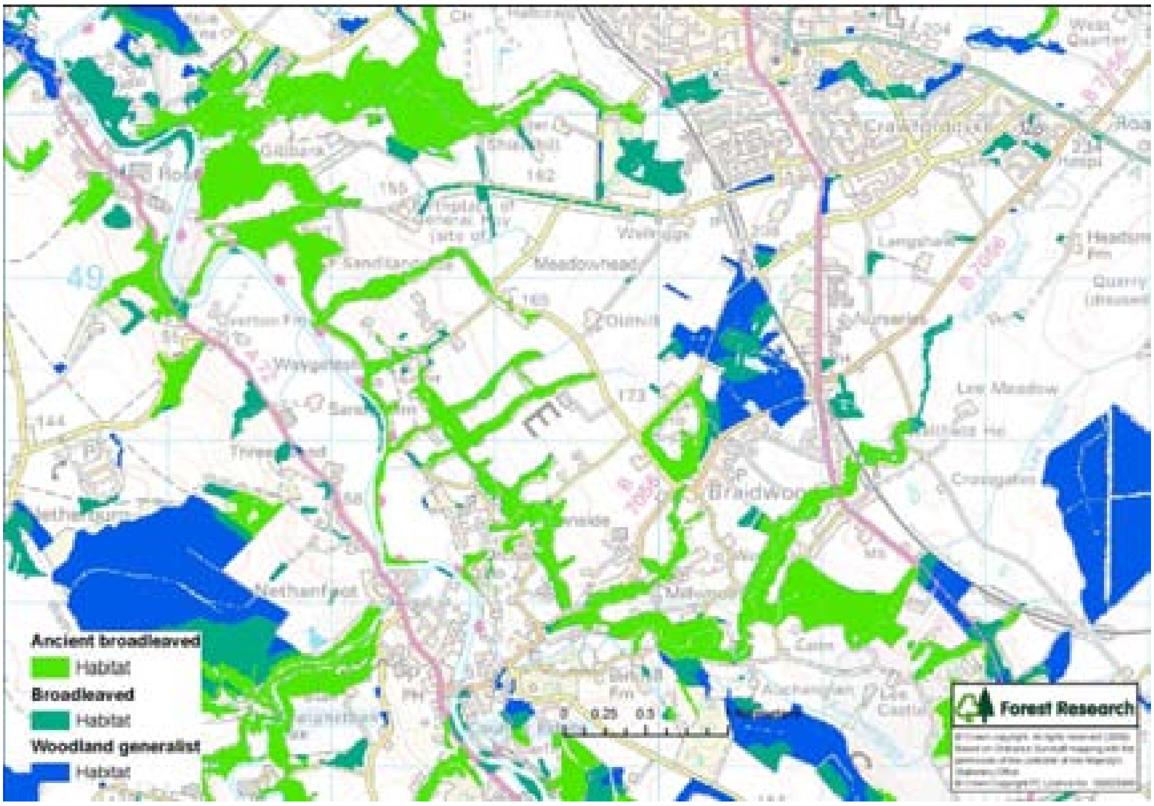


Figure 13 Converted woodland to higher quality habitat.

Wetland networks

In developing functional flood plains and targeting actions for LBAP species, wetland successional processes also need to be considered (although beyond the scope of this project). This may include the development of temporal networks of ponds, fens and wet woodland to represent the full range of successional development of wetland habitats.

Wetland network metrics

Wetland Generalist

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	14 501	62 440	4.3	11 543
2km	4 126	95 656	23.2	22 443

Peat wetland specialist

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	878	35 413	40.3	8 208
2km	547	45 385	83.0	11 154

Mineral wetland specialist

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	14 487	33 588	2.3	5 077
2km	4 062	69 751	17.2	14 519

The issue of flood prevention and mitigation is high on the public agenda; Scottish Planning Policy (SPP) 7: Planning and Flooding aims to “prevent further development which would have a significant probability of being affected by flooding or which would increase the probability of flooding elsewhere.” It is becoming increasingly clear that the problem can no longer be solved by building ever higher flood defences and instead the emphasis must be on restricting development in the floodplain and pursuing ‘softer’, more sustainable methods of flood control. One aspect that has been attracting increasing attention is the potential for land use, and woodland in particular, to mitigate damaging floods. Wetlands, woodlands and woodland management practices have long been associated with affecting both the quantity and timing of stream flows, and there is a widespread belief that wetlands and woodland can help to reduce and smooth flood peaks. There are four main ways that wetland habitats could assist flood control

1. Delayed Floodplain Flows
2. Delayed Channel Flows
3. Delayed Soil Runoff
4. Increased Water Use

Maintaining and enhancing the peatland habitats and networks within the upland zones of the GCV will hold water in these important nature conservation value habitats and help prevent urban flooding (Figure 14). This may include the restoration of peatland sites that have been afforested, many of which are now no longer commercially viable. This will also allow for increased connectivity of these upland peatlands.

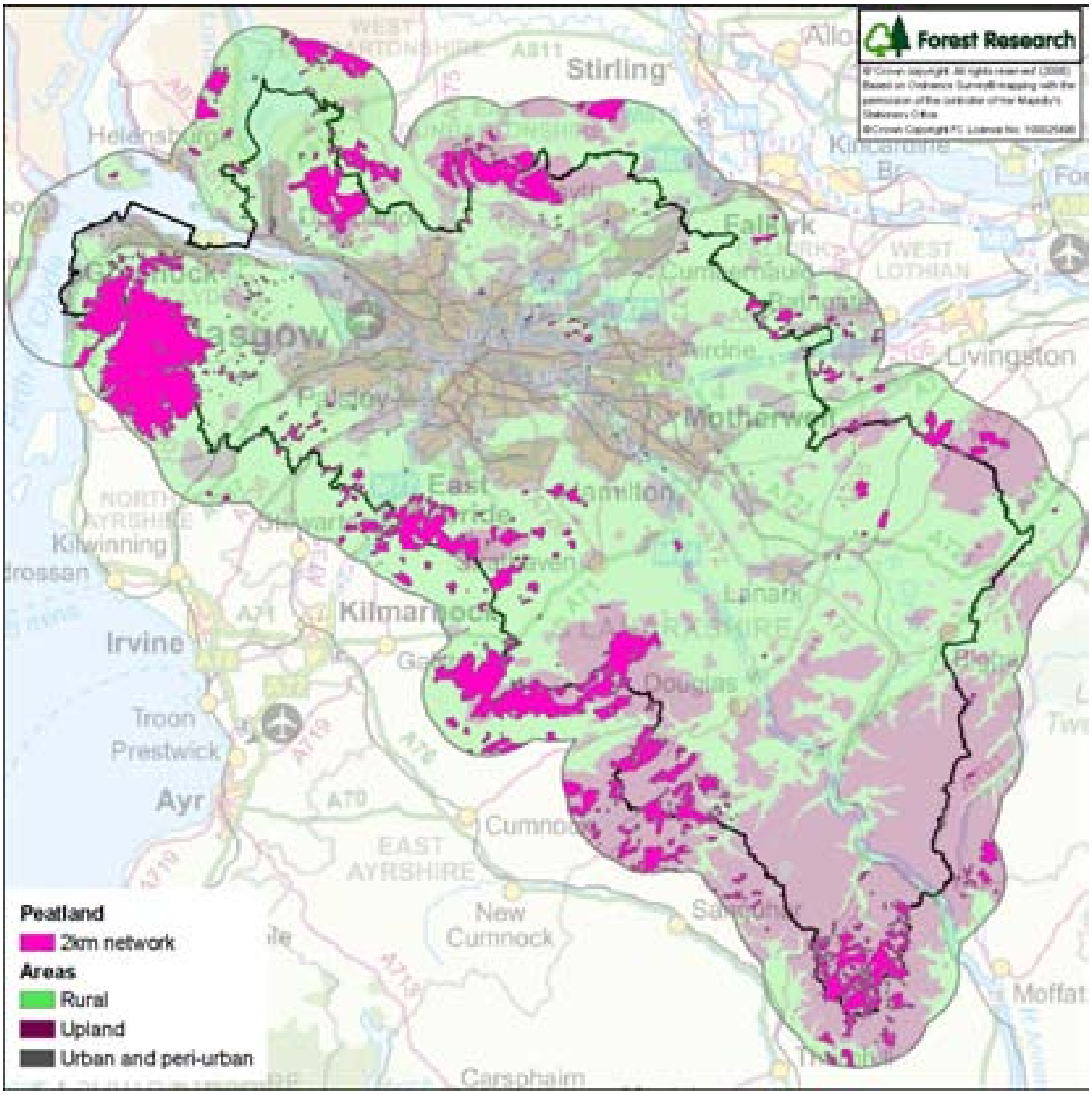


Figure 14 – Upland peatland networks in the GCV study area.

Moving into the rural, lowland zone, the wetland habitat and networks are on mineral-based soils, but the same principles of flood alleviation as outlined above apply. Whilst all the networks are locally important, limited resources focus attention on the priority enhancement areas (Figure 15), identified as for the woodland networks.

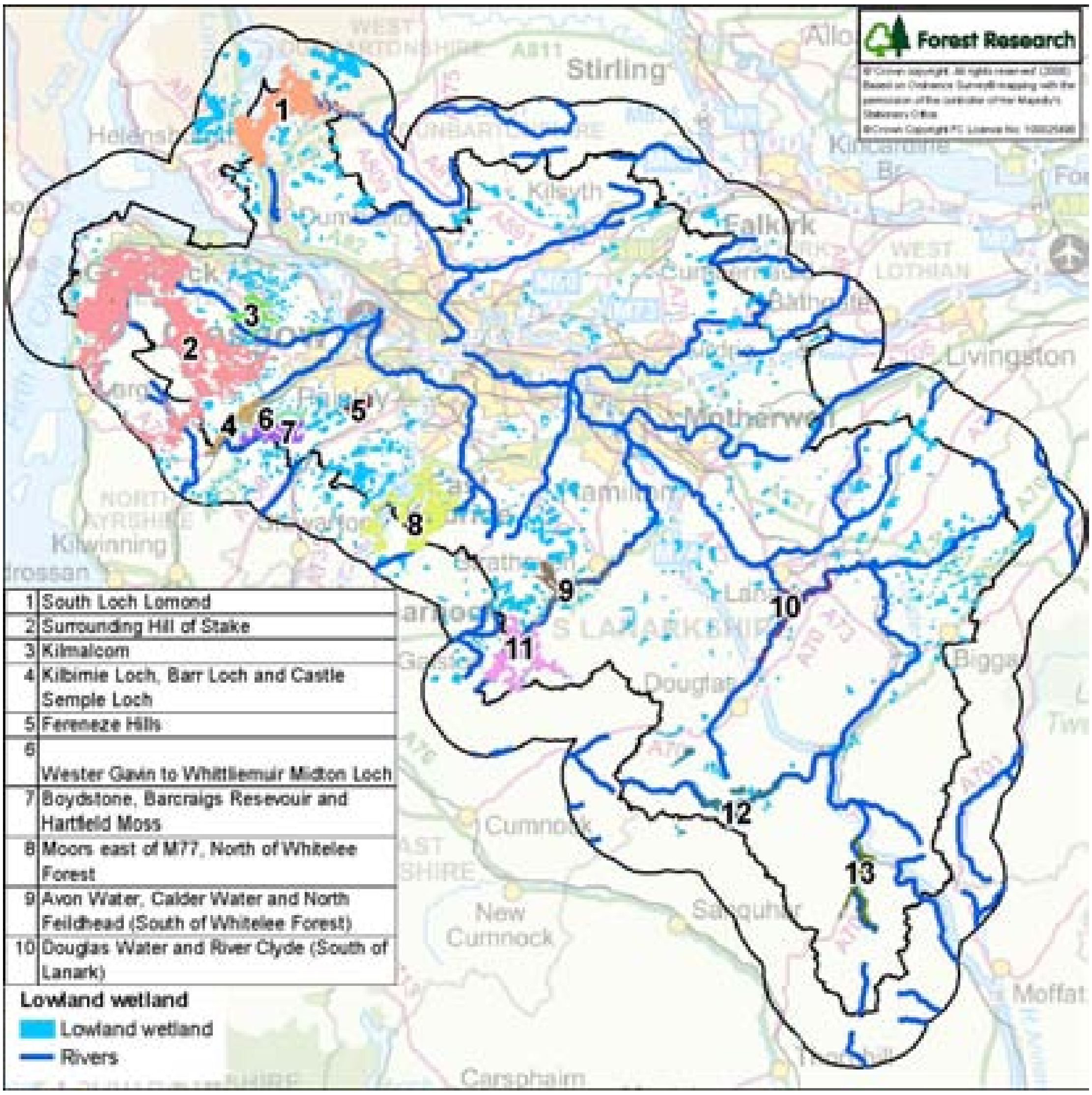


Figure 15 – Wetland habitat networks indicating where priority areas (each shown in a different colour) for wetland restoration can be targeted to improve connectivity.

Within urban areas, the integration of new greenspace through the planning process using spatially located Sustainable Urban Drainage Systems (SUDS) could also help to enhance the biodiversity of riparian and wetland areas (Figure 16) by introducing new areas of habitat. The development of habitat networks is seen as an important mechanism for reversing the effects of fragmentation on biodiversity while delivering a range of other environmental benefits: in this case flood control. There is the potential to develop a more integrated approach to planning land-use change, which takes account of conservation objectives for the full suite of habitats and species associated with different types of land use while also addressing environmental issues. The aim would be to develop more sustainable methods of flood control that are also ecologically functional.

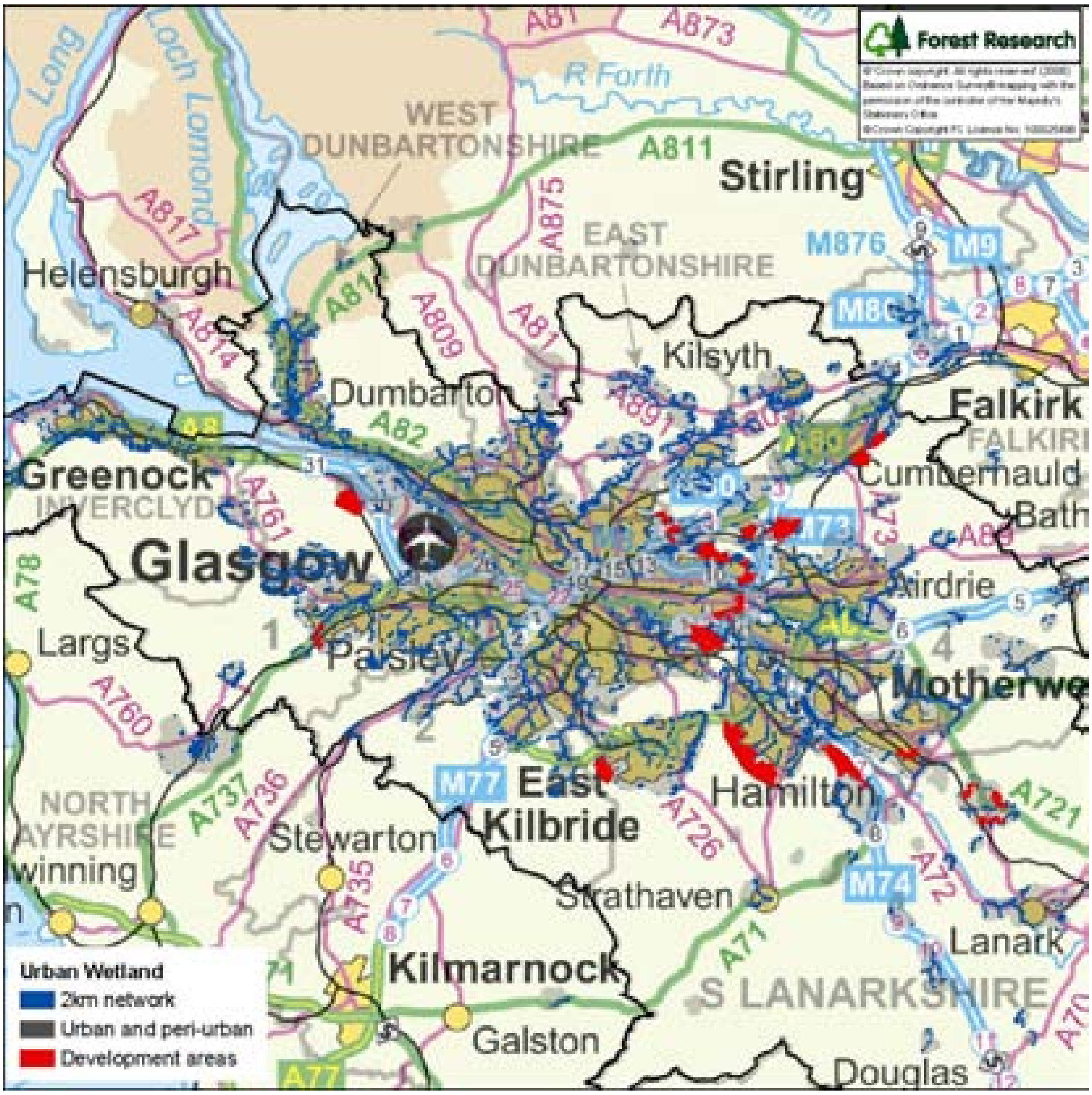


Figure 16 – Urban wetland networks and development areas within the GCV.

For example, part of the Gartloch / Gartcosh area has been designated for development; this could potentially impact upon the existing high-value wetland networks, but may also provide an opportunity for enhancement. Figure 17a-c show a scenario analysis from a) existing networks, b) development proposal incorporating additional wetland habitat, and c) resultant impact and enhancement of network area as a consequence of integrating the changes.

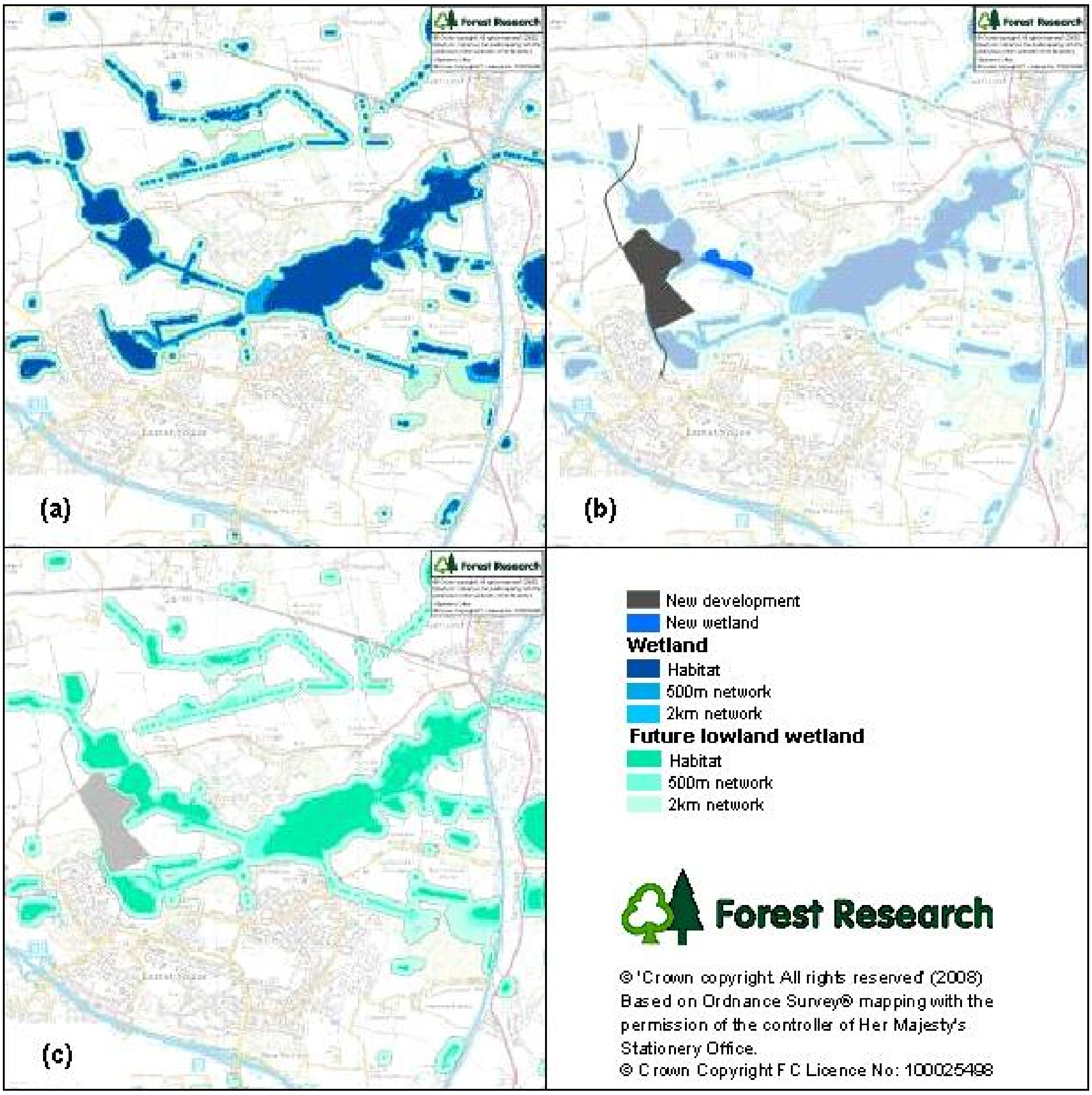


Figure 17a) Existing wetland networks b) Proposed development and new wetland as mitigation c) Enhanced habitat networks

4.2 Grassland networks

There are a large number of small grassland habitat networks within the GCV, but many of these are isolated from one another. The priority enhancement areas indicate where there are concentrations of these networks and these can guide strategies to improve functional grassland habitat network connectivity in the region (Figure 18). While these appear to be around the urban centre of Glasgow, they are very much within an agricultural setting and it is through the Scottish Rural Development Programme that enhancement can be implemented.

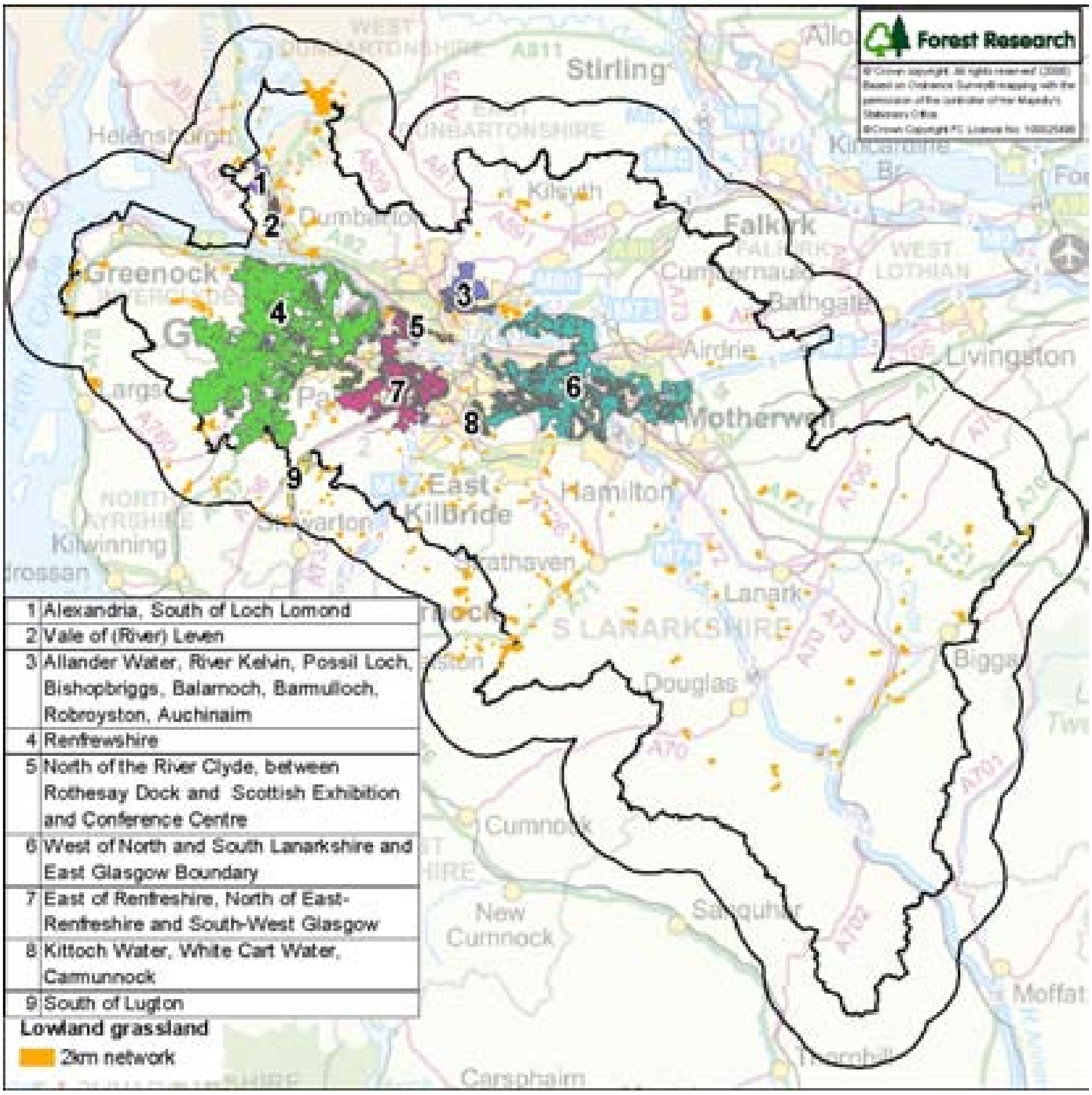


Figure 18 – Grassland priority enhancement (each shown in a different colour) areas for GCV.

Grassland network metrics

Generalist

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500	4 636	66 180	14.3	4 984
2km	1 259	114 738	91.1	14 045

Lowland

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	2 578	6 708	2.6	180
2km	754	19 122	25.4	916

Upland

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	511	39 561	77.4	3 008
2km	170	62 424	367.2	13 663

Lowland Acid Grassland

Max. dispersal distance (m)	Number of networks identified	Total area of networks (ha)	Mean area of networks (ha)	Area of largest network (ha)
500m	3 598	52 384	14.6	3 056
2km	1026	95 348	92.9	12 428

Modelling of semi-natural grassland networks can pinpoint fields with a high restoration potential where incentives could be targeted to help consolidate existing sites of high conservation value, for example SSSIs (Figure 19) with some unimproved grassland associated with them. Within these areas, the networks can be used to identify which fields are most likely to provide the greatest contribution to reducing fragmentation of the grassland habitat.

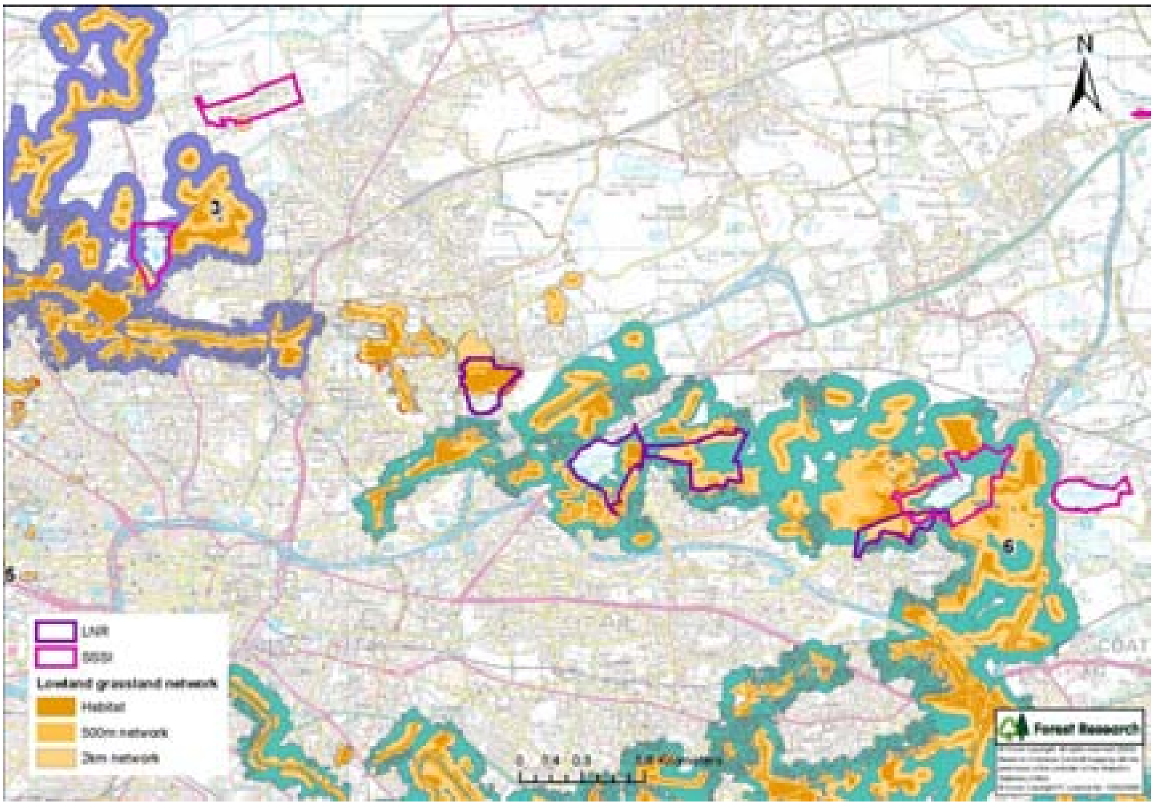


Figure 19 – Consolidating existing sites of high conservation value (e.g. SSSIs) using the lowland grassland networks (Priority Enhancement Areas each shown in a different colour).

The current distribution of 500m semi-natural grassland habitat networks are shown along with immediately joining fields (Figure 20), all of which have the potential to contribute to the habitat network. However it is not feasible or practical for this to be the case. A large proportion of this land will be intensively managed arable fields, which have had high nutrient and pesticide inputs and so restoration or conversion to unimproved grassland would not be practical either ecologically or economically.

Coincidence mapping, where 4 or more records of grassland quality indicator plant species occur (following JNCC Common Standard Monitoring Guidelines for Grassland SSSIs (JNCC, 2004)), can be used to identify 'nodes' where there may be grassland ecological processes persisting. Where a node coincides with a field that adjoins the grassland network area, then irrespective of whether that field is under grass or arable management, the potential for restoration is highest as it is more likely that there are remnants of grassland processes together with functional connectivity to nearby existing grasslands.

Areas for restoration should be targeted to reverse habitat fragmentation and recreate larger areas of grassland and transitions with other semi-natural habitats (Figure 21). Sites that have this potential for contributing to greater eco-integrity may be more suitable for restoration. A three stage approach to consolidating designated sites is proposed: a) protecting and enhancing the sites themselves; b) creating/restoring semi-natural grassland in fields that coincide with "nodes" (Figure 20); c) creating/restoring semi-natural grassland in fields that are part of, or adjoin, existing networks. SNH Natural Care Grants (which will be included as RDC tier 3 measures in the future) for consolidating designated sites could be spatially targeted using this three-stage approach.

Figure 20 – Distribution of "nodes" and priority fields for restoration.

Figure 21 – Development of grassland networks through targeted restoration of fields

4.3 Prioritisation of network applications

Integrated networks for range of habitats and focal species that reflect local landscapes can be used to prioritise conservation effort. Although networks derived using the BEETLE landscape ecology tool can highlight where there are interactions between different networks (Figure 22 and Figure 23), the model does not indicate the relative importance of these in terms of conservation priorities.

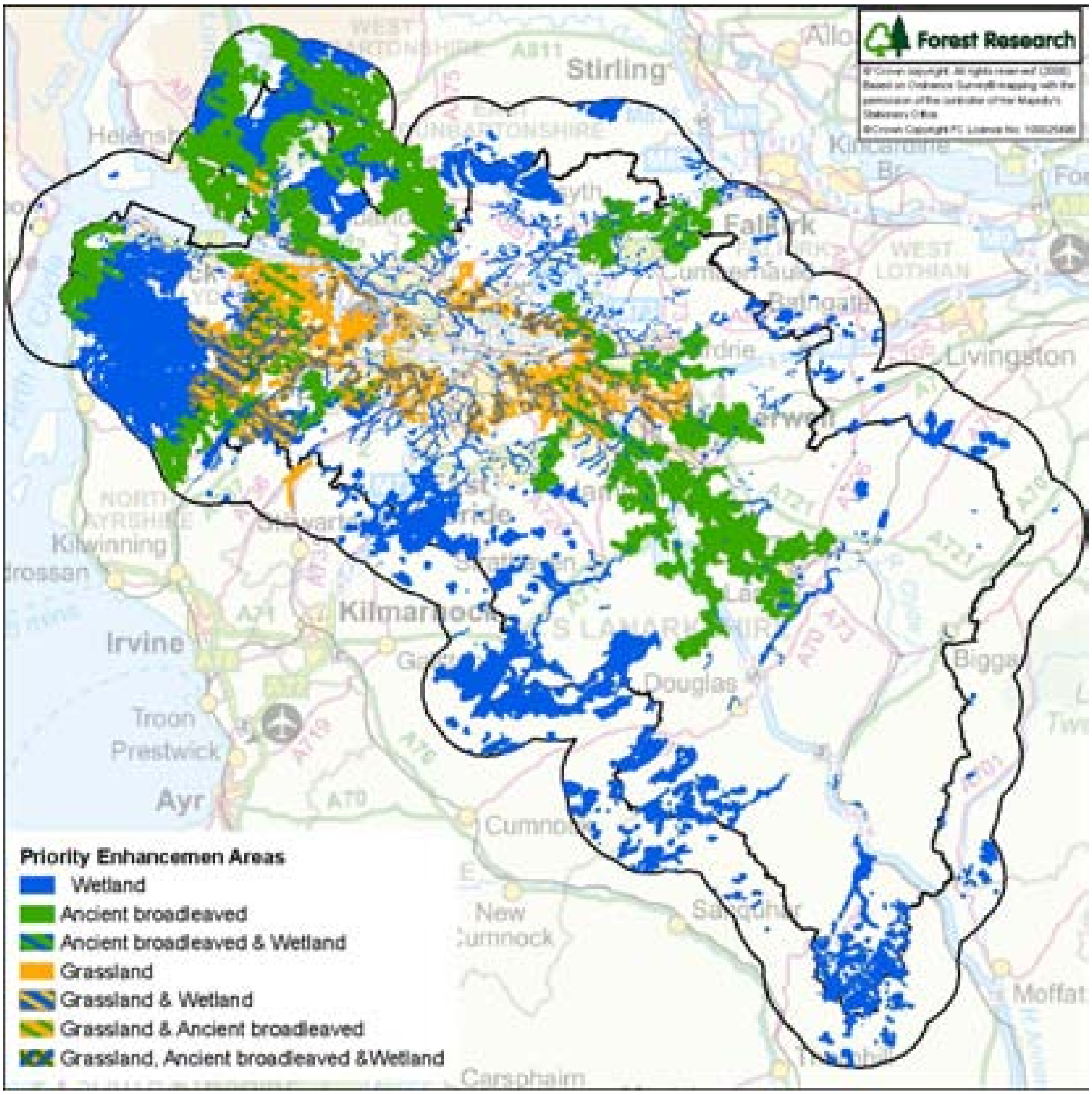


Figure 22 – Interactions between priority enhancement areas

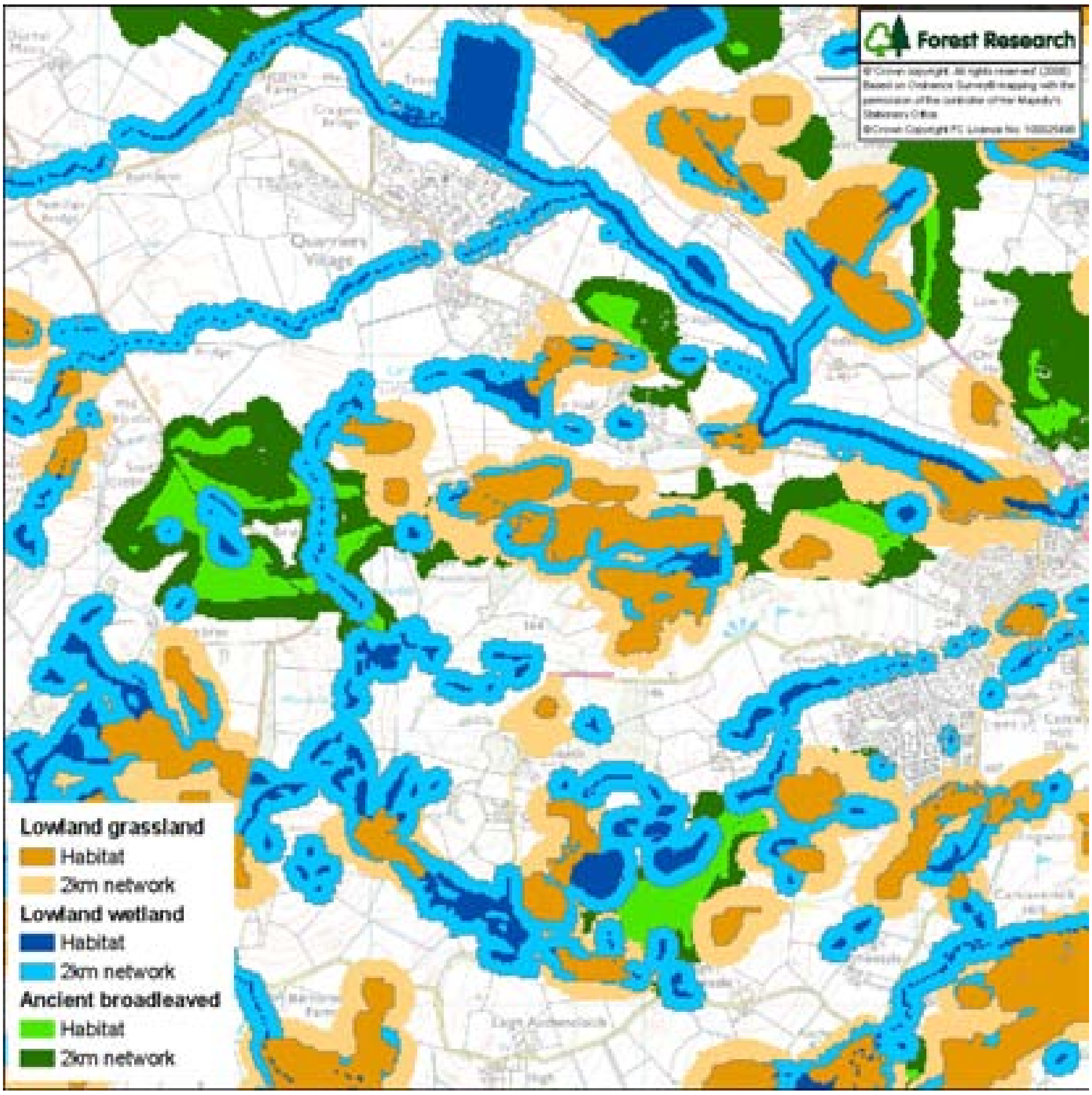


Figure 23 – Interactions between habitat networks at the local scale

A rule based multi-criteria analysis was developed to help with this prioritisation based on political priorities at different levels, e.g. local (LBAP) v regional (SBS) v national (UK BAP) and using the expert knowledge that exists at these different levels. The draft tables form part of the interaction with stakeholders and the components and values are open for discussion.

4.4 Integrating the GCV IHN with other regional Habitat Networks

GCV shares its boundaries with neighbouring habitat networks produced in Falkirk and Edinburgh & the Lothians, and Lomond and the Trossachs National Park, providing crucial links to create a truly integrated approach to enhancing biodiversity in central Scotland (Figure 24). The Priority Enhancement Area networks (1 – Lomond and the Trossachs, 3 – Cumbernauld to Falkirk, 10 – Cunninghame to Ayrshire) provide valuable opportunities for creating large linkages outside the GCV region.

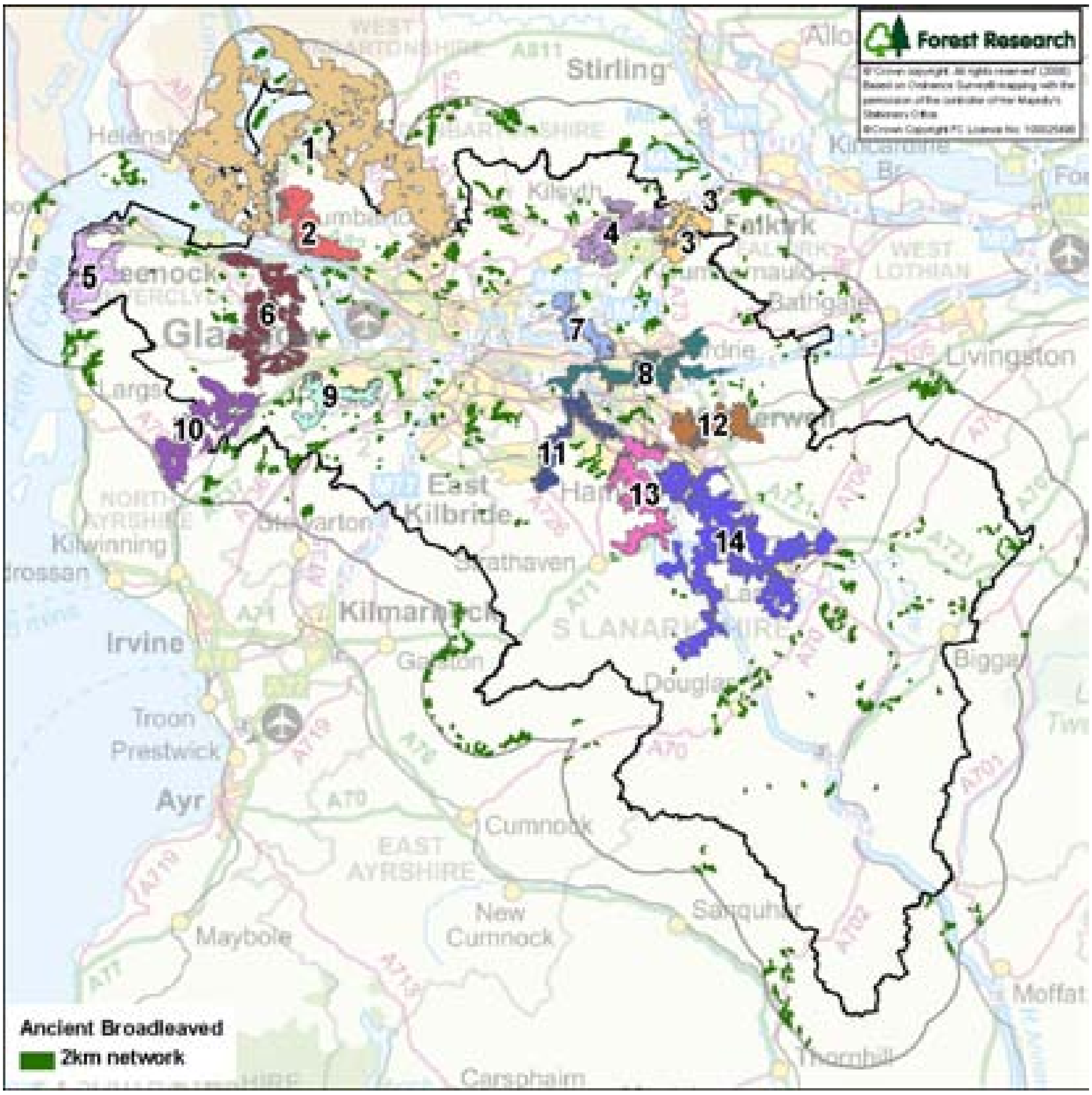


Figure 24 – Overlap of GCV IHN woodland networks with the Falkirk Unitary Authority and Lomond and the Trossachs National Park

4.5 Linking the integrated habitat network approach into the planning process

An integrated habitat network approach to deliver a range of benefits to meet environmental, economic and social targets is strongly supported within planning policies. The networks can inform the wider land-use planning process, contributing information and ideas to discussions during the detailed planning phase of development zones outlined in both the regional structure plan and local plans. IHN plans can also contribute information relating to the location, specification and types of habitat to complement and mitigate development impact, and protect and enhance biodiversity.

Planning Advice Note 65 – Planning and Open Space (Scottish Executive 2003) highlights the importance of woodlands in promoting biodiversity, and in the control of air and water pollution. Trees and woodlands also enable the movement of wildlife and people through networks in both urban and rural environments. Trees can also help to soften the impact of new developments, making green and civic spaces more appealing.

The National Planning Framework 2 (NPF2) discussion draft makes reference the integration of the network approach with a number of initiatives within the Central Belt, including the Central Scotland Forest. A substantial increase in woodland cover will improve landscape quality, biodiversity and amenity and help to absorb CO2. Improvements can also be made to networks of other habitats, including wetlands, to counter fragmentation and allow for changing patterns of species migration." Reference is also made to provision for recreation, particularly through the development of footpath and cycleway networks to encourage more active, healthier lifestyles. This should be developed through a Central Belt Green Network to "complement improvements in rail, road and communications infrastructure, making the Edinburgh–Glasgow corridor a more attractive place to do business." Clearly this is a valuable opportunity to create a larger, more robust network through links with other IHN. The NPF2 draft also suggests that green networks and community woodland initiatives be used to guide rehabilitation of brownfield sites

Additionally, the IHN plan can identify opportunities for FWAG or SAC action for landowners as well as prioritising community projects. The IHN outputs could then be used to examine how priority open ground and woodland habitats interact with the built environment.

The current suite of agri-environment measures in Scotland provides a framework for determining possible changes in agricultural practices and the scope for spatial targeting. Rural Development Contracts (RDCs) were introduced in 2005 and are a whole farm system of support, which makes payments for the delivery of environmental, social and economic benefits for public good. The RDC menu scheme is separate from past and existing agri-environment schemes, namely the Rural Stewardship Scheme (RSS), the Countryside Stewardship Scheme (CSS), the Environmentally Sensitive Areas (ESA) and Habitats Schemes. In 2007 all these schemes were superseded by the RDC Tier 3 scheme which will deliver tailored environmental benefits.

In addition, incentives are available for capital works such as pond construction, which will benefit invertebrates, and amphibians such as Great Crested Newt. Uptake of RDC Tier 2 and RSS measures are included within the IACS database and are therefore available for spatial modelling. Stakeholders were interested specifically in how measures could be spatially targeted to consolidate existing designated sites and habitat networks

Landscape effects

Although the human activity has dramatically changed the natural habitats and landscapes of the GCV, the pattern of land-use today continues to reflect the important natural influences of geology, climate, landform, drainage and soils.

Clearly, the impact on landscape character and the visual landscape from the development and expansion of, particularly, woodland habitat networks throughout the study area will be significant. The expanded habitat network, as projected by the BEETLE model will potentially impose a new and dominant spatial element on the field pattern. The new habitat will have the effect of reorganising the spatial experience of the landscape, and disrupt existing views of the area.

The implication is that from these representative selected viewpoints, views from settlements, individual dwellings, travel routes and vantage points could be potentially be affected by the habitat expansion proposals. If undertaken sympathetically, this can enhance visual amenity and enjoyment. Alternatively, if views of the landscape were obscured, filtered or reduced in extent, the inevitable consequence may be a loss of visual amenity. For people – be they residents, visitors or travellers – accustomed to the relatively open pastoral landscapes, there would be an appreciable reduction in their experience and enjoyment of the landscape. It is recommended, therefore, that planning of habitat change be undertaken in conjunction with a landscape assessment. In creating/expanding habitats new visual amenity will be created as well as current amenity lost, the relative value of those two situations is difficult to judge without speaking with people affected.

Ecological effects

Ecologically, those existing landscapes may be made up of a number of habitats, interdependent and creating a unity which is itself to be valued. To satisfy the requirements of one focal species would imply not only expansion of the appropriate habitat but also the spatial location of those features in the landscape and the overall relationship of one patch to another to influence the biodiversity value associated with the habitat for the selected species.

Clearly, the implications of considering the development and expansion of a woodland habitat network will have a potentially significant effect on the landscape. The above computer visualisations of the BEETLE model of that expanded habitat network illustrate both the potential extent and spatial implications of an expanded woodland cover. Also, an implicit consequence of such a significant shift in land-use balance between woodland and open ground is the potential implications for existing lowland habitat networks established throughout the farmland and other open ground areas.

Cultural effects

The GCV area became established as a centre of heavy industry during the Industrial Revolution, particularly the centre of a large iron and steel industry in the 18th and 19th Centuries. In the last 50 years or so the vast majority of the GCV's heavy industrial base has disappeared, with the economy of the region becoming increasingly services orientated.

Clearly, there will be potentially significant cultural implications of considering the development and expansion of an integrated habitat network throughout this study area. For example, an expansion of woodland habitat could potentially jeopardise the integrity of archaeological features where trees were established over them, but also potentially disrupt the appreciation of their relevance and context in the wider landscape. Local stakeholder engagement would be used to ensure that any potential negative effects on the integrity of archaeological and more recent post-industrial features would be taken into account in where and how the networks are developed

5. General discussion

Integrated habitat networks can deliver wider environmental and social benefits by providing increased opportunities for recreational access to the countryside and urban greenspace. For example, developing linear features as part of ecological networks such as riparian zones, buffer strips along field margins will also in theory encourage access, especially if farmers also apply for RDC Tier 2 subsidies for improving access. Current legislation (Land Reform (Scotland) Act 2003 – www.scotlandlegislation.hmso.gov.uk) provides rights of access to farmland and this is likely to be focused in wildlife rich areas both by accident and design as economic crops are excluded from rights of access. It is important to consider the positive benefits (i.e. greater access for viewing wildlife) as well as the negative ones (increased risk of disturbance to wildlife).

5.1 Taking forward the delivery of Integrated Habitat Networks in GCV

5.1.1 Implementation

This document forms the basis for determining the extent of the regional IHNs and provides a framework for identifying opportunities for improvement. The analysis and prioritisation of all areas for development is outside the scope of this project but clearly forms the next step for implementation. Refinement of the data used in the project is an additional area to be considered; this may be undertaken through a service level agreement. It is suggested that an approach examining networks for people and biodiversity would ensure that strategies to improve greenspace access for people and integrated into the biodiversity networks. These issues will be addressed through on-going work that has been identified: in running scenarios for the individual local authorities within the GCV area and updating the landcover layer as more digital data becomes available.

The statutory and policy framework for biodiversity conservation in Scotland (e.g. the UKBAP, the Nature Conservation Scotland Act 2004, and the Natural Environment and Rural Communities Act 2006), places a duty on landowners and public bodies to maintain and restore important semi-natural habitats where practicable, and to implement measures in the wider landscape to enhance biodiversity. Translation of these principles into on the ground action requires synergy between Local Authority Development Plans, RDCs, the LBAP process, landowners and advisors.

The IHN approach has a role in helping to guide the spatial targeting of actions to restore and enhance biodiversity. The availability of the tool to land use planners and advisors should help with the practical implementation of networks. Procedures are in place to get plans working on the ground. For example, FWAG and SAC are involved in whole farm conservation audits and the provision of advice to farmers as to what prescriptions and habitat management actions would potentially be best to implement on the farms. Recreation and landscape analysis could also help identify constraints and opportunities and are essential elements within the planning process. Further research in relation to some of the issues outlined below would help to address these issues.

5.1.2 Multifunctional aspects of an Integrated Habitat Network approach

The wetland analysis can be used to indicate areas where expansion and creation of habitat suitable for a range of wetland species could benefit the functional connectivity of existing networks. There is a valuable opportunity for wetland creation close to urban areas to complement, and be a part of, Sustainable Urban Drainage systems (SUDS) both for new developments and any retrofitting of SUDS. Local Plans can guide where these opportunities may be incorporated within development areas, by determining where they overlap, or are adjacent to, IHNs.

5.1.3 Recreation and access to greenspace

In addition to providing benefits for species dispersal and reducing habitat fragmentation, Integrated Habitat Networks encompass a range of greenspace and recreational opportunities. Greenspace comprises all urban open space ranging from public and private greenspaces to accessory open space along roads and railway lines. Access to greenspace is a vital part of land use planning, linking homes with local amenities and providing a sense of community. The promotion of greenspace can attract people into their local natural environment by improving community access, recreation opportunities and environmental and ecological quality close to, and within, communities (e.g. CABE Space, 2004). Reviews of greenspace usage support the hypothesis that local access to safe natural greenspace and attractive scenery is associated with high levels of physical activity within communities (Bird, 2007), and can benefit mental health, leading to a significant improvement in self-esteem, depression and mood (Pretty et al., 2007; Mind, 2007).

Interaction with greenspace allows people to identify with, and value, the greenspace in their neighbourhood, which can transform environmental quality in former run-down urban areas, with a corresponding increase in the economic value of the area and a stimulation of economic activity and investment (Anon 2005; Luther & Gruehn, 2001). Such evidence holds much weight with decision-makers, but it is often the less tangible values of greenspace which local people may most readily identify as important in their lives. These include benefits that improve people's quality of life such as community cohesion, empowerment and development (Land Use Consultants, 2004). Active participation in projects that aim to increase the quality or functionality of greenspace can enhance these benefits (see also DTLR, 2002).

Sustainable development as part of land use planning considers environmental, social, economic and cultural dimensions (Maruani and Amit-Cohen, 2007; Anon, 2007). In particular, the recognition of the value of greenspace within urban areas in Britain has led to the publication of planning documents, setting out guidelines identifying, protecting and encouraging its use, e.g. SPP11 – Physical Activity and Open Space (Scottish Executive, 2006); Enhancing Urban Greenspace (NAO, 2006). There is general acceptance that greenspace has a role in both naturalistic (e.g. biodiversity friendly) and formal landscape planning in the UK (Özgüner et al., 2007). Planning Advice Note 65 (PAN 65) – Planning and Open Space (Scottish Executive, 2003) highlights the importance of greenspace in promoting social interaction, sustainable planning, and improving the environment. For example, woodlands can; promote biodiversity, and help control air and water pollution. Trees, woodlands and other semi-natural environments can also enable the movement of wildlife and people through networks in both urban and rural environments. Greenspace can also help to soften the impact of new developments, making green and civic spaces more appealing.

5.1.4 Data

Incorporating the OS MasterMap data into landcover allows high spatial definition of landcover boundaries to be analysed. Although this high level of detail increasing GIS processing time, it does allow for a much greater level of detail to be incorporated within the urban environment. For example, it allows for permeability of gardens of differing sizes to be assessed. The biodiversity contribution of gardens is beginning to be appreciated and quantified with larger gardens found to be more likely to have a greater range of landcover types, vegetable patches, and trees over 2 metres in height present, indicating a potential for higher biodiversity. However, it is recognised that small gardens can behave like parts of larger gardens, contributing a larger interconnected network of greenspace. There is also evidence of a general trend of increasing garden size in relation to house type from terrace to semi-detached to detached. The antiquity of gardens is also likely to be a factor, with older gardens likely to have been managed to include a range of landcover types. This was assessed in GIS looking at the relationship between area of house to garden using OS MasterMap data and age of development (making the assumption that larger gardens in general are older, contain a wider range of structure type and are more permeable.

OS MasterMap provides accurate spatial information and provides a uniform basis for integrating the IHN outputs into existing planning systems, but it lacks detailed habitat information. Ideally, Phase 1 habitat information should be the minimum requirement for focal species modelling work as it informs the location and extent of semi-natural habitat. Without Phase 1 information, modelling can still be carried out using detailed woodland datasets, but it will lack the more complex open habitat details. There are still large areas of the GCV area where Phase 1 data is required in digital format (Figure 25); these they are currently being digitised by SNH and will be incorporated into future analyses. Good quality aerial photography is now available for Scotland and efforts should be made to translate this into an updated land cover map.

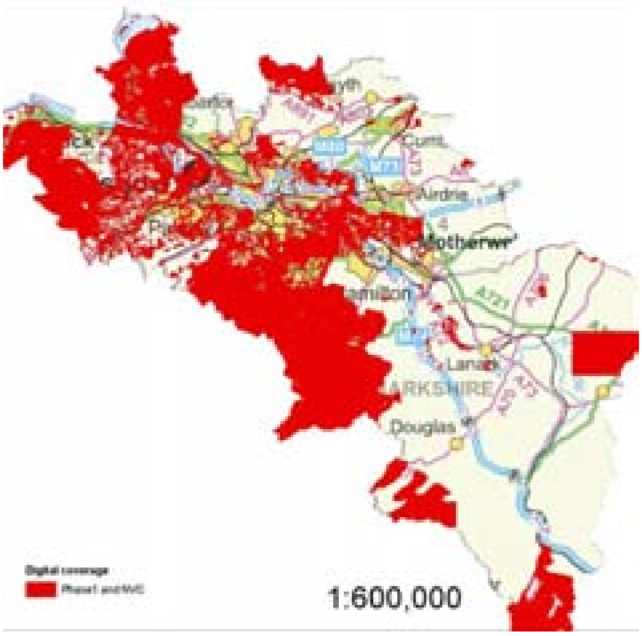


Figure 25 – Map of current digital coverage of GCV area

Where maps have not been digitised under contract for SNH, FR have been capturing high biodiversity value habitats and comparing them with the up to date IACS data to asses where possible. This is a very time consuming process and takes longer than was anticipated but again the increase in quality of the resulting product is well worthwhile.

This first iteration is likely to be very different to those undertaken with the imminent arrival of a new update of digital landcover data. FR and GCVGN have agreed a second phase of the project which includes an update of the data sets and a rerun of the BEETLE model to produce more accurate outputs.

6. Conclusions and recommendations

6.1 Use of the IHNs

- Integrated Habitat Networks (IHNs) were defined, for species using woodland, wetland, or grassland habitat, as landscape structures through which species can disperse freely between numerous habitat patches. These networks can be used to prioritise conservation effort

- The Integrated Habitat Networks should be used within a GIS as part of the decision-making process; they do not provide answers on their own

- The strength of the IHN approach lies in taking account of local conservation priorities and making best use of local expertise. Engaging with local stakeholder groups has been vital part of this process and enables the networks to relate to local on-going projects

- Priority Enhancement Areas can be used to identify opportunities where effort can be undertaken to strengthen existing habitat networks

6.2 Delivery mechanisms

- LBAPs, Single Outcome Agreements, and SNH Natural Futures provide appropriate scales and mechanisms for determining network priorities and for informing the regional targeting of agri-environment incentives

- Delivery of the network requires tech transfer to the biodiversity officers and planners and this will be addresses through the dissemination project

- The implementation of habitat networks requires the integration of local and national policy conservation priorities and planning mechanisms with network modelling and “on- the-ground” advice and execution

6.3 Habitat creation

- Areas of new habitat should be as large as possible and of high quality and structural complexity. It is recognised that many opportunities will be constrained by the size of area available, but should aim towards:

- Within all of the urban fringe, and particularly within the Core Development Areas, planners and developers should be encouraged to take every opportunity to protect existing and add new open ground and woodland; to safeguard the biodiversity of the region, mitigate the impact of climate change, and improve community landscapes. This should be over and above the duty of planning authorities “to ensure planning permissions make adequate provision for the preservation or planting of trees”, as stated in section 159 of the Town and Country Planning (Scotland) Act 1997 (Scottish Executive 1999). An additional recommendation is that, where development involves the loss of trees, permission should normally be conditional on a replanting scheme with trees of appropriate species in appropriate numbers.

- Woodland planting on development sites should be substantial; 150m width will eventually provide 50 m of core woodland conditions. This is the minimum recommended size for new woodland. The planting of street and ornamental trees will have little impact on improving the woodland biodiversity of the region. Under these circumstances, development would only increase the fragmentation of neighbouring woodland habitat.

- Grassland habitat networks may be enhanced by the creation of small areas of high quality species-rich grassland as these can act as stepping stones for grassland species.

- New developments should endeavour to ensure Space for People targets, suggesting accessibility to woodlands of 2 ha or more within 500 m, are not compromised.

6.4 Visualisation

- Computer generated visualisations of network development could provide a useful tool for evaluating the likely impacts on the visual aspects of landscape character. These outputs can help with the consideration of landscape constraints and subsequent refinement of the IHN outputs

- The manipulation and interpretation of oblique aerial photographs could be of value as a tool for communicating the visual impact of network development at a larger scale and to a wider group of stakeholders

6.5 Data

- The availability of good land cover data is also essential for the modelling. Phase 1 survey information on semi-natural habitats is the main data requirement. It is recommended that Phase 1 be reviewed and supplied in digital format for the whole of the region. Once data has been improved, the changes could be incorporated into the landcover data set and the network analyses re-run

- Habitat and land cover surveys should be undertaken to update and improve landcover data, particularly for Phase 1 surveys

6.6 Further development

- The modelling of “people networks” would add to the planning of a green network approach, enabling targeted improvement of greenspace to achieve multiple objectives

- Methods for monitoring the success of habitat network implementation and development include: assessing habitat condition and ecosystem development, tracking the distribution and dispersal of both focal and functional species, recording evidence of species use of new habitats and undertaking post-hoc genetic analysis to infer patterns of migration

- Ecosystem development should be monitored to provide feedback on the effectiveness of improvement strategies.

- The concept of applying a multi-criteria analysis to prioritise IHNs should be explored through consultation with an assembled group of biodiversity officers, agency staff, and planners. Further development will be required through engaging a wider number and range of stakeholders (NGOs, landowning bodies (NFU / SRBPA), funding bodies, COSLA, to determine which of the factors are considered influential.

- Integration of the IHN to inform future reviews of the GCV Councils: Development Plan; Biodiversity & Development Supplementary Planning Guidance, e.g. site specific surveys to reflect wider IHN implications including LBAP, Derelict Land, and Central Scotland Forest

- The timing of reviews of other plans would enable a review of the IHN / data update to be undertaken to contribute to these reviews

References

Anon. (2005) *WIAT: Woodlands in and Around Towns.* Forestry Commission and Scottish Executive, Edinburgh, Scotland.

Anon (2007) *Delivering Quality Greenspace: A Guide to Better Green space*. Ironside Farrar report for Glasgow and Clyde Valley Green Network Partnership, 53 pp.

Bird, W. (2007) Natural Fit: Can green space and biodiversity increase levels of physical activity? RSPB.

Bruinderink, G. G., Sluis, T. van der, Lammertsma, D., Opdam, P., Pouwels, R. (2003) *Designing a coherent ecological network for large mammals in Northwestern Europe.* Conservation Biology, 17: 549-557.

CABE Space (2004) *Green Space Strategies – a good practice guide.* Department of Communities and Local Government. 44 pp.

Fleishman, E., Jonsson, B.G. and Sjögren-Gulve, P. (2000) *Focal species modelling for biodiversity conservation.* Ecological Bulletins, 48, pps 85-99.

Freudenberger, D. and Brooker, L. (2004) Development of the Focal Species Approach for Biodiversity Conservation in the Temperate Agricultural Zones of Australia. Biodiversity and Conservation, 13, pps 253-274.

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 Scottish Natural Heritage and Forestry Commission Scotland/GB: 2004/2005. Forest Research.Roslin, Midlothian.

Humphrey, J.W., Smith, M., Shepherd, N. and Handley, P. (2007) Developing Lowland Habitat Networks in Scotland: Phase 2 Contract report to Forestry Commission Scotland, Forestry Commision GB, Scottish Natural Heritage and Scottish Executive Environment and Rural Affairs Department. Forest Research. Roslin.

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

Land Use Consultants (2004). *Making the links: greenspace and quality of life.* Scottish Natural Heritage Commissioned Report No. 060 (ROAME No. F03AB01).

Luther, M. and Gruehn, D (2001) *Putting a price on urban green spaces,* Landscape Design, No. 303, pp 23-25.

McGarigal, K., Cushman, S.A., Neel, M.C. & Ene, E. (2002) FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst. In: www.umass.edu/landeco/research/fragstats/fragstats.html

Maruani, T. and Amit-Cohen, I. (2007) *Open space planning models: A review of approaches and methods.* Landscape and Urban Planning, 81, pp 1-13.

Mind (2007) Ecotherapy: The green agenda for mental health. http://www.mind.org.uk/NR/rdonlyres/5C3A20ED-F084-4958-A58D-C935DCD6732D/0/executivesummary.pdf Accessed 07/04/08

Moseley, D.G., Ray, D. and Bryce, J. (2006). A Forest Habitat Network for the Atlantic Oakwoods in Highland Region, Scotland. Botanical Journal of Scotland, 57(1&2), 197-209.

Moseley, D.G., Ray, D., and Watts, K. (2007) Improving Forest Habitat Networks with new woodland planting schemes. Forestry & British Timber January 2007, p 14-18.

NAO (2006) *Enhancing Urban Greenspace.* Office of the Deputy Prime Minister. The Stationery Office, London 76 pp.

Özgüner, H., Kendle, A.D. and Bisgrove, R.J. (2007) Attitudes of landscape professionals towards naturalistic versus formal urban landsapes in the UK. Landscape and Urban Planning, 81, 34-35.

Pretty J, Peacock J, Hine R, Sellens M, South N, Griffin M (2007) Green exercise in the UK Countryside: Effects on Health and Physiological Well-Being, and Implications for Policy and Planning. Journal of Environmental Planning and Management, 50(2), 211-231

Ray, D., Watts, K., Griffiths, M., Brown, C. & Sing, L. (2004) *Native woodland habitat networks in the Scottish Borders.* Forest Research, Roslin. Contract report to Forestry Commission, Scotland.

Ray, D. & Moseley, D.G. (2006) A *Forest Habitat Network for* Edinburgh and the Lothians. Unpublished report to Midlothian Council, City of Edinburgh Council, East Lothian Council, Forestry Commission Scotland, and Scottish Natural Heritage.

Scottish Executive (2003) *Planning and Open Space: Planning Advice Note (PAN) 65.* http://www.scotland.gov.uk/Publications/2003/01/16188/16553

Scottish Executive (2006) *Scottish Planning Policy: SPP 11: Physical Activity and Open Space Consultation Draft* http://www.scotland.gov.uk/Publications/2006/08/10134711/0

Watts, K., Griffiths, M., Quine, C., Ray, D. & Humphrey, J.W. (2005) *Towards a Woodland Habitat Network for Wales.* In. Countryside Council for Wales, Bangor.

Further reading

Forestry Commission Information Note 073 Evaluating biodiversity in fragmented landscapes: principles

Forestry Commission Information Note 085 Evaluating Biodiversity in Fragmented Landscapes: Applications of Landscape Ecology Tools

Forestry Commission Information Note 089 Evaluating Biodiversity in Fragmented Landscapes: Use of Focal Species.

Appendix I

Definitions

AWI	Ancient Woodland Inventory
BEETLE	Biological and Environmental Evaluation Tools for Landscape Ecology
CSFT	Central Scotland Forest Trust
CSS	Countryside Stewardship Scheme
DEM	Digital Elevation Model
EC	European Commission (now European Union)
ESA	Environmentally Sensitive Areas
FCS	Forestry Commission Scotland
FWAG	Farmland and Wildlife Advisory Group
GCV	Glasgow and Clyde Valley
IACS	Integrated Agricultural Control System
IALE	International Association of Landscape Ecology
IUCN	International Union for Conservation of Nature
IHN	Integrated Habitat Network
LBAP	Local Biodiversity Action Plan
NBN	National Biodiversity Network
NIWT	National Inventory of Woodland and Trees
NNRs	National Nature Reserves
NPF2	National Planning Framework 2
NPPG 14	National Planning and Policy Guidance 14
NVC	National Vegetation Classification
NWM	Native Woodland Model
RDB	Red Data Book
RDC	Rural Development Contracts
RPAC	Rural Project Assessment Committees
RSBP	Royal Society for the Protection of Birds
RSS	Rural Stewardship Scheme
SAC	Scottish Agricultural College
SAC	Special Area of Conservation
SBS	Scottish Biodiversity Strategy
SEERAD	Scottish Executive Environment and Rural Affairs Department
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
SPA	Special Protection Area
SPP	Scottish Planning Policy
SSNWI	Scottish Semi-Native Woodland Inventory
SSSIs	Sites of Special Scientific Interest
SUDS	Sustainable Urban Drainage Systems
SWT	Scottish Wildlife Trust
UK BAP	UK Biodiversity Action Plan
W & CA	Wildlife & Countryside Act
WIAT	Woodlands in and around towns

Appendix2

Glasgow and Clyde Valley (GCV) Integrated Habitat Network Stakeholder workshop

Mike Smith & Darren Moseley, Forest Research

06/02/07 Nye Bevan House, Glasgow

Attendees

(Bob This bits For you)

Introduction

Aim of workshop

The aim of the workshop was to identify the key conservation issues within the Glasgow and Clyde Valley (GCV) case study area (Figure 1) and to tease out the most important species and habitats that could be used in the BEETLE model to develop an Integrated Habitat Network (IHN).

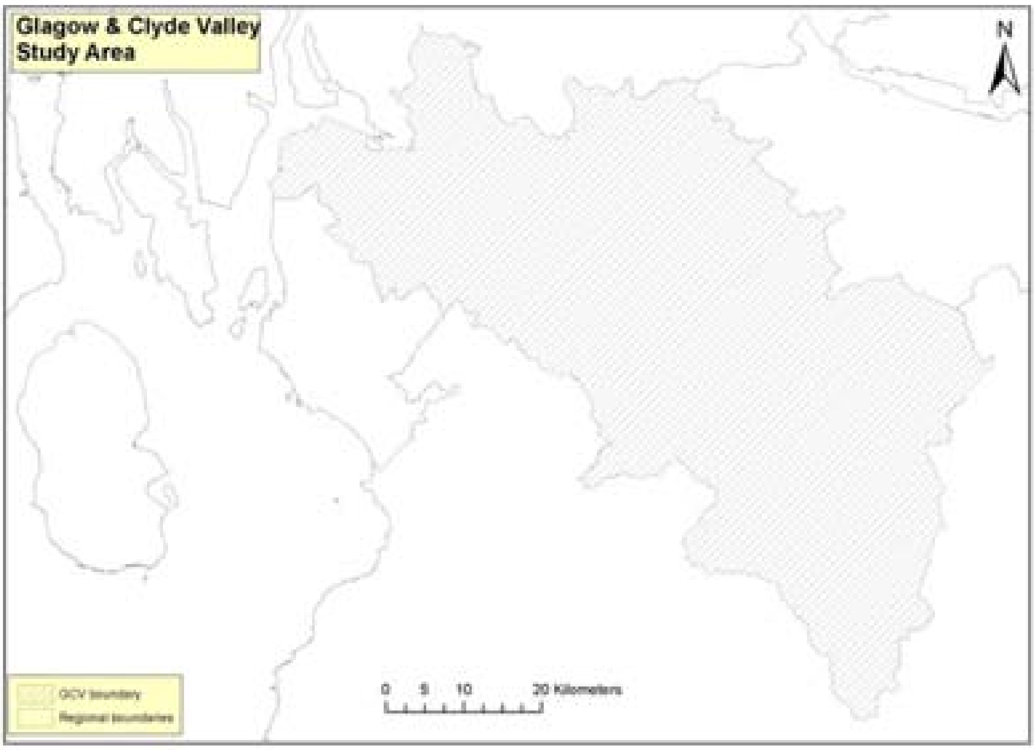


Figure 1. Study area for the Glasgow & Clyde Valley Integrated Habitat Network.

BEETLE modelling presentation

Darren Moseley and Mike Smith presented the principles of the accumulated-cost distance application of the BEETLE suite of tools, with some examples of how these can be applied to address conservation and biodiversity issues. One of the objectives was to show that species autecology is a very important component in determining the focal species used to construct a robust model to define IHNs using the BEETLE approach.

There then followed a more general description of the modelling process, which proved useful as it allowed those with little knowledge of the modelling process to become more familiar with the concept and its potential applications. It is thought that this is an area where more detail could be added to future presentations.

Other GIS tools / remote sensing applications were then looked at to see how to target areas for potential restoration within network areas. For example, the OS 1st edition map can be used to highlight areas of past habitat were restoration is likely to be more successful. Another methodology was the use of coincidence mapping of species based on information held on Recorder by the environmental record centre based on the work carried out on unimproved grasslands in Fife. This also showed how the IHN approach could be used to target Land Management Contracts and the consolidation of Designated sites

Workshop on developing an Integrated Habitat Network

The workshop was split into threes groups, which were led by Penny cousins Bob Frost and Darren Moseley, with Mike Smith moving between the groups. Initially each participant was asked to identify 3 issues of conservation concern, which were then discussed within the workshop group to see if there was relationship between these issues and the development of an IHN. Species and habitats that were of thought to be of relevance to an IHN were then discussed and whether there was the expert knowledge (and who held this knowledge) on these for use within the BEETLE modelling approach.

Each Group had a set of maps showing

- AO format map of case study areas
- Case Study designated sites
- Wetland areas (open water, swamp, marshy grasslands, etc.)
- Unimproved and semi-unimproved grasslands
- Peatlands (dry/wet heaths and blanket bog)
- Woodlands

These maps of areas were used to identify issues and information that would be useful for the development of an IHN and also allowed this information to be located geographically. Contact details of relevant experts were also included on this map (IHN contacts database is in the process of being constructed). This information was then collated and is summarised below:

Highlighted Conservation issues of concern.

The first element of the workshop asked each the participants to identify 3 areas of conservation concern within the case study area. Although these could be ordered by strategic level (national, local or habitat network) or by issue, the latter is probably more useful as the main part of the workshop was to examine these issues and relate them to the concept of IHNs.

Wetland management

This is the biggest issue raised in the GCV area and encompasses a wide range of topics that come together under the Floodplain Management banner

- Loss/fragmentation/lack of lowland floodplain wetland features.
- Loss/fragmentation/lack of riparian/wet woodland
- Distribution of ponds
- Loss of habitat for breeding waders
- Potential for further wetland expansion
- Flood Control

These topics are all inter-related through ecological succession in that ponds become wetlands which will eventually become wet woodlands. It is proposed that these successional relationships are investigated both spatially and temporally through using the BEETLE model. This may help with decision making that allows for management of ecologically functional floodplains.

Potential wetlands focal species were members of the Odonata family and the water vole. It may be more useful to use Newt species as there is good autecology for these species and the fact they use a range of wetland habitats at different stages of the year.

Flood Control

Flood prevention and mitigation is high on the public agenda. It is becoming increasingly clear that the problem can no longer be solved by building ever higher flood defences and instead the emphasis must be on restricting development in the floodplain and pursuing 'softer', more sustainable methods of flood control. One aspect that has been attracting increasing attention is the potential for land use, and woodland in particular, to mitigate damaging floods. Wetlands, woodlands and woodland management practices have long been associated with affecting both the quantity and timing of stream flows, and there is a widespread belief that wetlands and woodland can help to reduce and smooth flood peaks. There are four main ways that wetland habitats could assist flood control:

1. Delayed Floodplain Flows

2. Delayed Channel Flows

3. Delayed Soil Runoff

4. Increased Water Use

The development of habitat networks is seen as an important mechanism for reversing the effects of fragmentation on biodiversity while delivering a range of other environmental benefits: in this case flood control. There is the potential to develop a more integrated approach to planning land-use change, environmental issues. The aim would be to develop more sustainable methods of flood control that are also ecologically functional.

Woodlands

The woodlands of GCV are varied, comprising narrow shelterbelts, estate woodlands, ancient woodland remnants in river gorge settings, and more recent conifer plantations. Woodlands with high biodiversity are typically the remnants of what was once a more extensive cover, which has become fragmented over centuries as a result of land clearance for farming. This process has accelerated over recent decades with the adoption of more intensive farming practices, and the spread of settlements and transport infrastructure. Management and expansion of existing woodlands are now needed to conserve the remaining woodland biodiversity, and ensure its future viability and integrity. This is particularly urgent, as pressures of climate change will require some species to move to avoid local extinction.

It is thought that woodland should be split into different habitat types either by management type or by Habitat Action Plan types.

Orchards and Wood pastures

The orchards, wood pasture and their often high biodiversity value trees are under recorded across GCV, modelling of these unrecognised and under-valued habitats could investigate the Inadequate/discontinuous supply of deadwood for hole-nesters and saprophytes and the continuity of veteran and orchard trees.

Farm woodlands

Shelterbelts in the agricultural landscape have the potential to contribute greatly to wooded habitat networks and their importance should not be undervalued. Hedgerows and hedgerow trees can also contribute in a similar way.

Wet woodlands

These are important in relation to the wetland networks as well as the woodland ones.

Ancient woodland

These long-established woodlands are important sources of biodiversity, often providing nodes for future dispersal events.

Conifer woodland

Conifer woodland constitutes a large component of the wooded landscape and is important for red squirrel issues.

Unimproved grassland

This is a key habitat in the case study area and had been in serious decline as a result of agricultural improvement over the last 60 years. Some species and issues:

- Hare
- Grass margins
- Small patch size
- Coincidence mapping list spp.
- Core 2nd 3rd level sites within networks and supporting existing sites
- Amenity grassland management issues

Peatlands

These were raised as important habitats of the upland fringe.

Other Issues

Planning Process

Semi-natural habitats can fill the important role of softening new urban areas, providing a natural link between the urban and the surrounding landscape, and bringing wildlife into urban settings. Design criteria set down in Local Plans and in Habitat Network principles will guide developers to achieve robust landscape frameworks as well as detailed landscape and access requirements for the new communities. Planning applications will be expected to address these issues, and the guidelines provided will apply in all circumstances.

IHNs can potentially influence the planning process in a number of ways, including:

- Guidance for planners
- Master plans
- Vacant and Derelict land

Climate change

The BEETLE model can be used to address some of the issues that relate to species and habitats in relation to climate change these could include sea level changes, coastal erosion, and identifying suitable areas for managed retreat.

Species management in relation to climate change can also be addressed using the BEETLE model. There are several issues that relate to this, including whether a proactive or reactive approach should be taken to address species change as a result of climate change. For example:

- Species predicted to have an extended northern distribution e.g. nuthatch, certain butterflies spp. Should we look to be accommodating potential new arrivals?

- Species that are southern end of their distribution. Should we target these species as they are likely to disappear anyway?

Or should we look to creating checks in the system as and when changes are seen to be occurring and react as a result of these.

Invasive species

These are riparian issues in many ways but are being treated separately since the use of the modelling tools may well be able to address these issues but it is thought that this is not within the scope of this project – indeed it is a project all of its own.

- Invasive non-native plant species in the riparian zone.
- Japanese knotweed,
- Himalayan balsam
- Giant hogweed
- water vole
- mink
- riparian/ WFD River corridors

Balancing Priorities

It is envisaged that investigation into the relationship between different habitat networks to derive an IHN. While the BEETLE cannot resolve issues relating to the interaction between these habitats, it will highlight where these issues occur. In this way woodland, wetland, heathland, and other habitat networks can be overlaid to see where the interactions between networks exist.

Agri-environment issues

Targeting of Agri-environment grants was raised by several of the participants and, while it is a broader national issue, it is one the modelling will hope to be able the help with and is part of the wider remit of the project. The case studies will investigate how this could be achieved in differing lowland situations related to:

- Change in agriculture/agri economics will result in changes in land use and habitat change. It will be possible to look at different scenarios in an attempt to predict how this might affect connectivity between different habitats

Data issues

The importance of good, reliable, species autecology and land cover data cannot be over emphasised, as it is this aspect that will give the model credibility. Data issues were discussed and the collation of this will be a very important part of the ongoing IHN project in the GCV.

Conclusions

There will not be time to run the BEETLE model on all of the above and so there will need to be a targeting exercise in consultation with stakeholders and steering group to select a reasonable number that can be investigated within the context of the project.

It is suggested that the following be selected for BEETLE modelling

- Unimproved grassland
- Floodplain management wetlands using newts as the focal species
- Woodland Habitats using different woodland types

That these will be looked at in terms of

- Functional connectivity
- Targeting of agri-environmental incentives
- Their relation to designated sites
- Balancing priorities/resolving conservation conflicts
- In relation to the planning process