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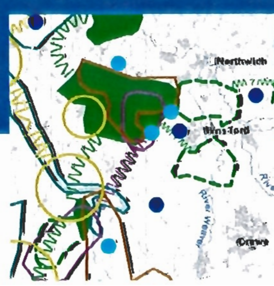
Networks for LIFE

Scenario development of an ecological network in Cheshire County

S.A.M. van Rooij
E.G. Steingröver
P.F.M. Opdam



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ABSTRACT

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In this report, a vision for ecological networks in Cheshire County is developed and presented. This vision is developed in close interaction with the County Council. The vision contains a proposal for sound ecological networks of meres and mosses, heathland, rivers, woodland and grassland.
A standardised method is presented and applied, integrating the following information in the scenario:

° demands for different ambition levels for sound ecological networks;
° abiotic potencies for ecosystems in the County;
° the opinion of key stakeholders;
° future developments in infrastructure and urban planning;
° opportunities for nature development.

According to future developments and information, the resulting scenario can be adjusted easily with the information provided. In the report also information for further refining the scenario is provided.

Keywords: Ecological networks, scenario development, biodiversity, spatial planning

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Preface

Cheshire County Council has commissioned a research project to ALTERRA to develop a scenario for an ecological network in Cheshire County, United Kingdom.

We would like to thank the LIFE-ECOnet team of Cheshire County Council. Especially thanks to the project leader Ian Marshall and Steve Clarke, whose frequent input and quick responses contributed greatly to the result of this project. Also many thanks to the rest of the LIFE ECOnet team, Mike Wellman, Alun Evans and Kate Horsley who inventoried the stakeholders opinions on spatial options for nature development, and gave their valuable input in a joint workshop.

We are also grateful to Theo van der Sluis, who carried out an analysis of the present landscape, and who was closely involved in this study. He has shared with us his wide ecological knowledge of Cheshire and on the data available for the study area.

Summary

Chapter 8 consists of a summary of the proces and results presented in this report.

1 Introduction

1.1 Concept of ecological networks

Biological diversity is highly dependent on the quality, quantity and spatial cohesion of natural areas. Fragmentation severely affects the abundance of species.

If wildlife is spread over large areas, in low numbers, and if these remaining areas are too small, wildlife species will disappear sooner or later. To allow for repopulating or restocking of small areas and habitats, the areas need to be connected to the remaining core areas for wildlife in the vicinity (Romano 2000). For birds, this means that the distance from source areas to their habitat is less than the normal distance they might cover when flying. For non-flying animals it might mean that often a physical connection is required, e.g. forests, streams, rivers, natural grasslands and so forth.

An answer to this problem is the development of an ecological network, linking nature areas by means of corridors and small habitat patches. An ecological network is constituted of physically separated (physically separated contradicts the paragraph above that states that a physical connection may be required) habitat patches, for a population of a particular species that exchanges individuals by dispersal.

The development of ecological networks is part of European policy (Bern Habitats Directive, Natura 2000), and has resulted in the development of the Pan European Ecological Network PEEN. European ecological networks especially can be beneficial for large herbivores like red deer, or top predators like wolves, bear, lynx and otter. However, in the first instance many small organisms will benefit from improvements in spatial cohesion and expansion of natural habitats.

Many European countries are attempting to realise ecological networks at a national or regional scale. The LIFE-ECOnet Project is a practical example of this approach at the regional scale. This four-year demonstration project is supported by the EU LIFE-Environment Programme, and aims to integrate environmental considerations in land use planning through the use of ecological networks. The project is the joint initiative of local authorities, private industry and research centres from the UK, Italy and the Netherlands.

1.2 Objective of this project

For the county of Cheshire, the spatial distribution and cohesion of five ecosystems in the present landscape have been analysed using LARCH (van der Sluis *et al.*, 2003). These ecosystems are: meres and mosses, heathland, rivers, woodland and grassland. The next step is to develop a long-term vision (scenario) for a sustainable ecological network in the County.

In this report, the development of a long-term vision of sustainable ecological networks of the selected ecosystems in Cheshire County is set out and described. For the design of such a vision, a method for applying ecological guidelines for sustainable networks in multifunctional landscapes is used (Opdam *et al.*, in prep.). Based on the information in this report, other scenarios can be composed that are adapted to changed conditions and insights.

Based on the long term vision of an ecological network in the County, a GIS-map of a scenario, that comprises sustainable ecological networks for meres and mosses, heathland, rivers, woodland and grassland ecosystems is made. This GIS-map is then used as input for testing the designed scenario against the LARCH model (van der Sluis *et al.*, 2003).

1.3 Definitions of terms

Carrying capacity: the maximum population of a species that a specific ecosystem can support indefinitely without deterioration of the character and quality of the resource, i.e., vegetation or soil.
Dispersal capacity: Capacity of most individuals of a species (80%) to bridge distances to new, potential habitat.
Ecological network: network constituted of physically separated habitat patches, for a population of a particular species or a set of species with similar requirements, that exchanges individuals by dispersal.
Habitat: an area that can support living organisms for at least part of its life cycle
Habitat patch: spatially defined area of habitat for a species.
Key patch: a patch with a carrying capacity large enough to sustain a key population, and close enough to other patches to receive, on average, one immigrant per generation.
Key population: a relatively large, local population in a network, which is persistent under the condition of one immigrant per generation.
Local population: small population of at least one pair, in one habitat patch, or more habitat patches within the home range of a species. A local population on its own is not large enough to be sustainable. In this report with a local population is meant to define an area large enough (sufficient habitat) to support a local population.
Metapopulation / Network population: a set of local populations in an ecological network, connected by inter-patch dispersal.
Minimum Viable Population (MVP): a population with a probability of exactly 95% to survive 100 years under the assumption of zero immigration.
Persistent or viable population: a population with a probability of at least 95% to survive 100 years.
Scenario: Image of a desirable and possible future situation.
Spatial cohesion: a relative measure that can visualise the weakest parts in the ecological network for a certain species.
Sustainable (habitat) network: a habitat network that can support a sustainable network population.
Viable population: see persistent population.

2 Method and structure of report

2.1 General introduction on ecoprofiles

For the development of guidelines for spatial cohesion of habitat for animal species, the concept of 'ecoprofiles' for the sensitivity to fragmentation of habitat has been used. An ecoprofile is a description of the spatial and qualitative requirements of a surrogate species, which represents a range of species with similar demands. The large variety of species that can be present in a landscape is thus reduced to an orderly number of ecoprofiles. These ecological profiles differ in their sensitivity to fragmentation of habitat (Table 1; Vos *et al.*, 2002).

Table 1 Ecological profiles differ in the amount of required habitat area for a viable population and in their dispersal capacity[1] (after Vos et al., 2002)

Dispersal capacity / **Required habitat area**			
	- Low extinction risk - Limited dispersal capacity	- Low extinction risk - Intermediate dispersal capacity	- Low extinction risk - Large dispersal capacity **Least vulnerable for fragmentation** *(e.g. common sandpiper)*
	- Intermediate extinction risk - Limited dispersal capacity	- Intermediate extinction risk - Intermediate dispersal capacity	- Intermediate extinction risk - Large dispersal capacity
	- High extinction risk - Limited dispersal capacity **Most vulnerable for fragmentation** *(e.g. tree frog)*	- High extinction risk - Intermediate dispersal capacity	- High extinction risk - Large dispersal capacity *(e.g. large birds)*

[1] Dispersal capacity = Distance that most individuals of a species can cover by undirected movement to a possible colonisation area.

2.2 Method

The method, which is innovative and undergoing development, is described in Opdam *et al.* (in press). The procedure and different steps of this method and their mutual coherence are shown in Figure 1. The designing of an ecological network is used as a case-study to validate this method.

The different steps of the method and data used are listed below, with a brief description of the procedure that is followed:

Analysis of ecological networks in present landscape
A recent analysis of the ecological network of five different types of ecosystems in Cheshire county is used and relevant data are summarised (van der Sluis *et al.*, 2003).

Abiotic conditions
A number of maps are available and are used to identify areas with high potential for the development or restoration of good quality habitat.

Step 1 Choice of ecosystem types and objectives
In discussion with the Life ECOnet Project Team it is decided to explore the possibilities for sound ecological networks for a number ecosystems and their order of priority in those cases where the spatial structure of ecosystem development coincide on the same location.
Ambition levels for the objectives are set by the Life ECOnet Project Team for each ecosystem. A minimum ambition level is derived from the extrapolation of current policies. A more ambitious ambition level is estimated by the Life ECOnet Project Team.

Step 2 Choice of target ecoprofiles for selected ecosystems
Based on the analysis of the ecological networks in the present situation and on expressed ambition levels, a set of target ecoprofiles is selected in discussion with the ECOnet Project Team. Target ecoprofiles are those ecoprofiles for which the present habitat network is non-sustainable, but with feasible efforts can become sustainable. The aim is to select two ecoprofiles per ecosystem, of which one represents species that are hindered in their movements by infrastructure, and one which is not.

Step 3 Generating spatial options for ecological networks
To achieve sustainable habitat networks for target ecoprofiles, spatial options are generated. Depending on the present situation and the abiotic conditions and potential, the following strategies can be used:
- Connecting patches or networks of patches
- Enlargement of patches
- Increasing the density of habitat patches
- Improving habitat quality in existing patches

On the basis of the generated spatial options, the ECOnet Project Team inventories the likes and dislikes of the most important stakeholders in the County regarding nature development. The ECOnet Project Team also assesses the opportunities and restrictions for nature development in the future as a result of developments in other functions as urban planning, waste disposal etc.

Step 4 Ranking spatial options

First, the generated spatial options are evaluated and ranked based on their spatial efficiency for the contribution to nature quality.

After that, the ranking is shifted, based on an analysis by the the ECOnet Project Team of the likes and dislikes of stakeholders and on the detected opportunities and restrictions. Herewith, the ecologically sound spatial options with support of stakeholders were detected for each ecosystem.

The next step is to combine options of each ecosystem into one scenario. Herewith, we aim for a structure of ecological networks in which networks of distinct ecosystems can contribute most to eachothers quality[2].

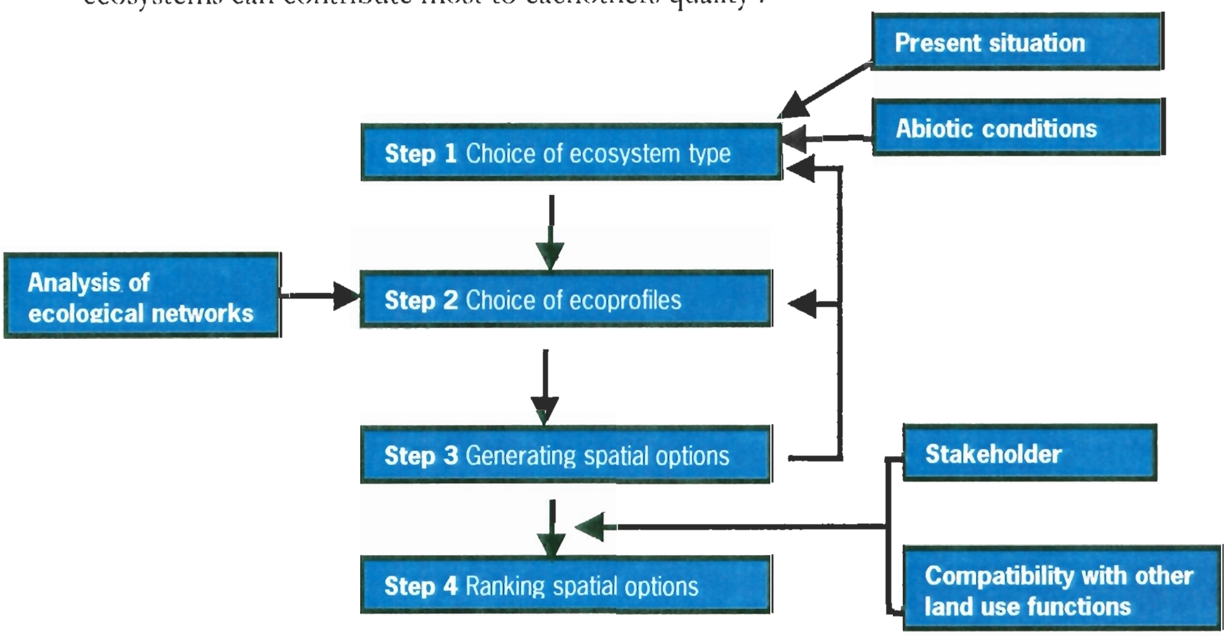


Figure 1 Flow diagram of method for planning ecological networks in multifunctional landscapes.

[2] E.g. by realising a joint network of woodland and heathland, the transition between and joint presence of these two types of ecosystems emerges, of which many species profit.

3 Earlier decisions and bandwidth for designing ecological networks

This chapter is the state of the art report of an early stage of the scenario making. Some of the presented assumptions appeared invalid in a later stage of the process, when new information became available. If so, adaptations of assumptions are put down later on in this report.

3.1 Meres and mosses

3.1.1 Present situation

Data collected on meres and mosses indicates that the theoretical maximum area that could be restored to suitable peatland habitat is 3,700 ha (Table 2, Figure 2).

Table 2 Data on area of potential or present peatland in Cheshire county

Data on meres and mosses	Area
Peat parcels currently supporting mire vegetation	1,700 ha
Peat with all semi-natural vegetation (i.e. Cheshire Peatland Inventory)	2,400 ha
Area of peat blocks (geological drift map)	3,700 ha

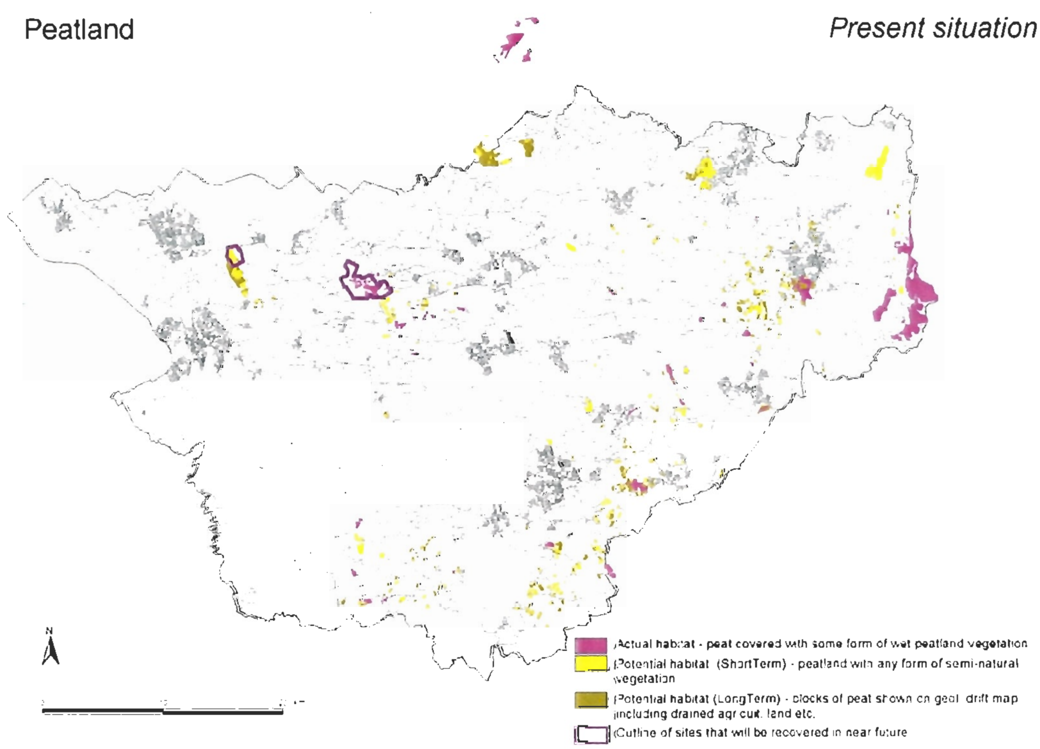


Figure 2 Actual and potential peatland in Cheshire county

The Forestry Commission's target for peat restoration in Delamere Forest consists of the restoration of all 22 peat bodies present, which cover a total area of 101 ha. In addition, the Cheshire Wildlife Trust has recently established a nature reserve on Gowy Marshes and is aiming to restore 164 ha out of 437 ha of peatland on the site.

3.1.2 Ambition levels

The low ambition level for meres and mosses is set at 270 ha, to be realised in Delamere Forest & Gowy Marshes. These hectares have already been assigned to specific, known areas, and therefore no additional spatial options are generated.

The high ambition level is set at the restoration of 2,100 ha, which includes the 270 ha. that will be realised in Delamere Forest & the Gowy Marshes. The remaining 1,830 ha. will be realised in wetland sites that contain peat parcels.

3.1.3 Decisions and assumptions

- The sites which were indicated as 'peat covered with some form of wet peatland vegetation' are considered to be good quality habitat for species of meres and mosses;
- Sites indicated as 'peatland with any form of semi-natural vegetation' and 'blocks of peat shown on geological drift map including drained agricultural land etc.' are considered to be unsuitable habitat for peatland species at present, but have the potential to be restored to good quality habitat for these species;
- The sites with 'any form of semi-natural vegetation' are considered to be sites that can be restored within a relative short term;
- The sites 'blocks of peat shown on geological drift map' that do not coincide with sites that are covered with wet peatland vegetation or any form of semi-natural vegetation are considered to be sites that can be restored in the longer term;
- In generating spatial options, we took into account that the restoration targets for Delamere Forest & Gowy Marshes will be realised in the near future; these sites are considered as good quality peatland habitat.

3.2 Heathland

3.2.1 Present situation

The Cheshire Heathland Inventory (1995) showed a total area of only 160 ha of heathland in Cheshire (60 ha lowland heath and 100 ha upland heath or moorland, Figure 3).

Lowland heathland restoration is confined to specific areas of Cheshire (< 250 m), upland moorland restoration is confined to the Peak District National Park and Peak fringe (> 250 m). Three different classes are suitable for heathland restoration in the long term: high, moderate and low potential sites. Survey work has shown that recent succession habitats (birch woodland and acid grassland) together with conifer plantations, could be converted back to lowland heath. These are high potential sites for heathland restoration in the short term (Figure 3).

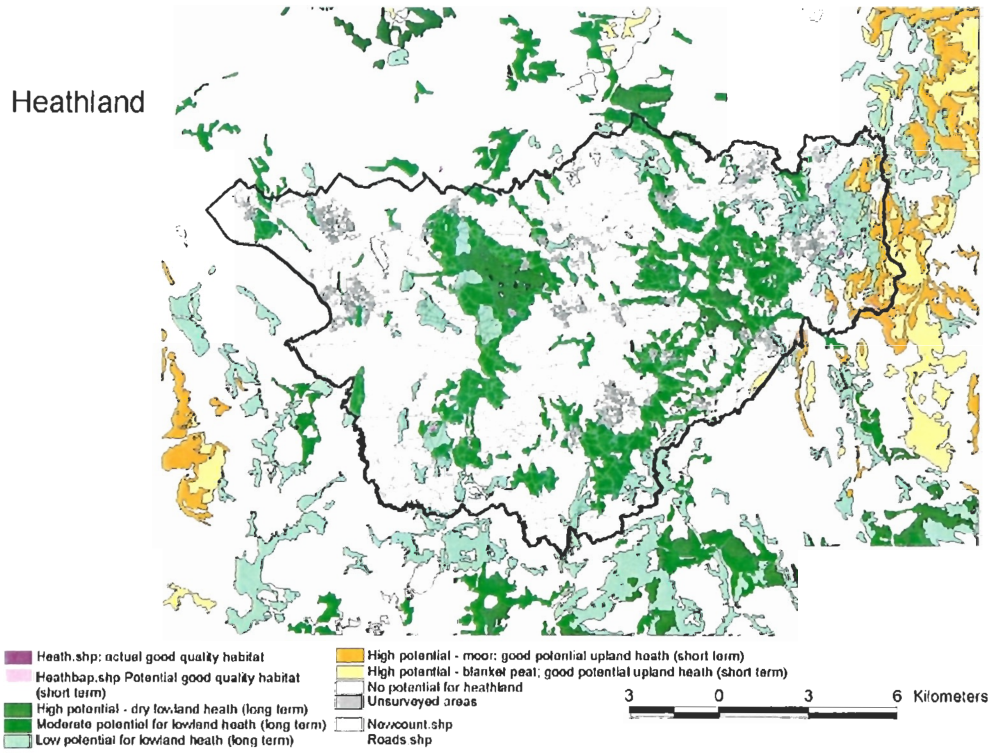


Figure 3 Actual and potential heathland habitat in Cheshire county

3.2.2 Ambition levels

Ambition levels for Cheshire are:
Low ambition level: increase of 250 ha
High ambitious level: increase of 500 ha
74 Hectares of conifer forest in Delamere Forest is to be converted to lowland heathland. No other hectares are already assigned to specific sites.

3.2.3 Decisions and assumptions

- Lowland heath is found in low-lying areas (< 250 m); all of Cheshire outside the Pennines
- The lowland area contains mostly dry heathland, sometimes in a mosaic pattern with wet heathland
- Upland heath is found in the higher areas (>250 m); in the Pennines
- It is of little use connecting areas of lowland heath with upland heath since most species are confined to one or other of these habitats

- Sites present in the shapefile *heath.shp* are considered to be high quality heathland sites
- Sites present in the shapefile *heathbap.shp* are considered to have high potential for restoration to high quality heathland sites in the short term
- Sites indicated as 'high potential – dry lowland heath' in the file *heathnc.shp*, are considered to have high potential for high quality lowland heath in the long term
- Sites indicated as 'moderate potential – dry lowland heath' in the file *heathnc.shp*, are considered to have moderate potential for high quality lowland heath in the long term (resulting in a mosaic of acid grassland and heathland)
- Sites indicated as 'low potential – dry lowland heath' in the file *heathnc.shp*, are considered to have low potential for high quality lowland heath in the long term
- Sites indicated as 'high potential – moor' and 'high potential – blanket peat' in the file *heathnc.shp*, are considered to have high potential for high quality upland heath in the short term (a change in grazing intensity can readily restore heathland habitat)
- Areas that are indicated as 'high potential – blanket peat' in the file *heathnc.shp*, have potential for quality upland heath in the short term; a change in the intensity of grazing can readily restore heathland habitat

3.3 Rivers

3.3.1 Present situation

Many large and smaller rivers flow through Cheshire County, draining into the tidal areas of the Dee and Mersey in the Northwest. In these areas there is potential for improving riverbank quality and rehabilitation of natural floodplains (Figure 4).

In Figure 5, the present suitable habitat for a wetland species is shown (Sedge warbler). This habitat reflects the presence of marshland in the lowland area. In the tidal floodplains, some vast suitable wetland areas are present. Along the rivers and around inland water bodies, only very small patches offer suitable habitat.

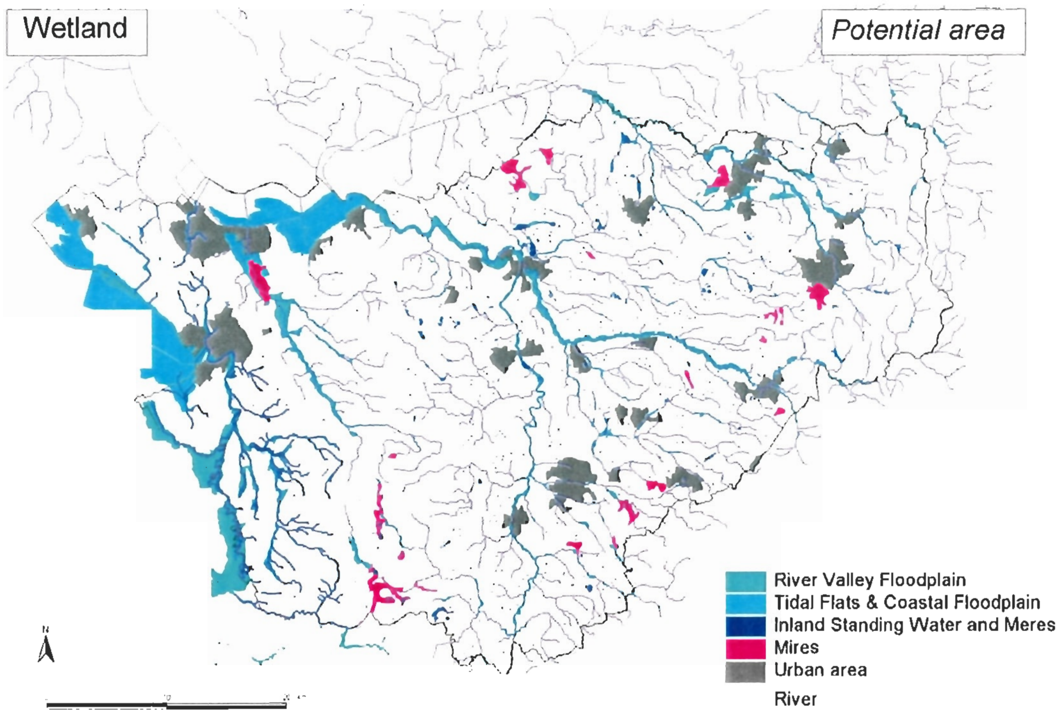


Figure 4 Potential area for rivers and floodplains

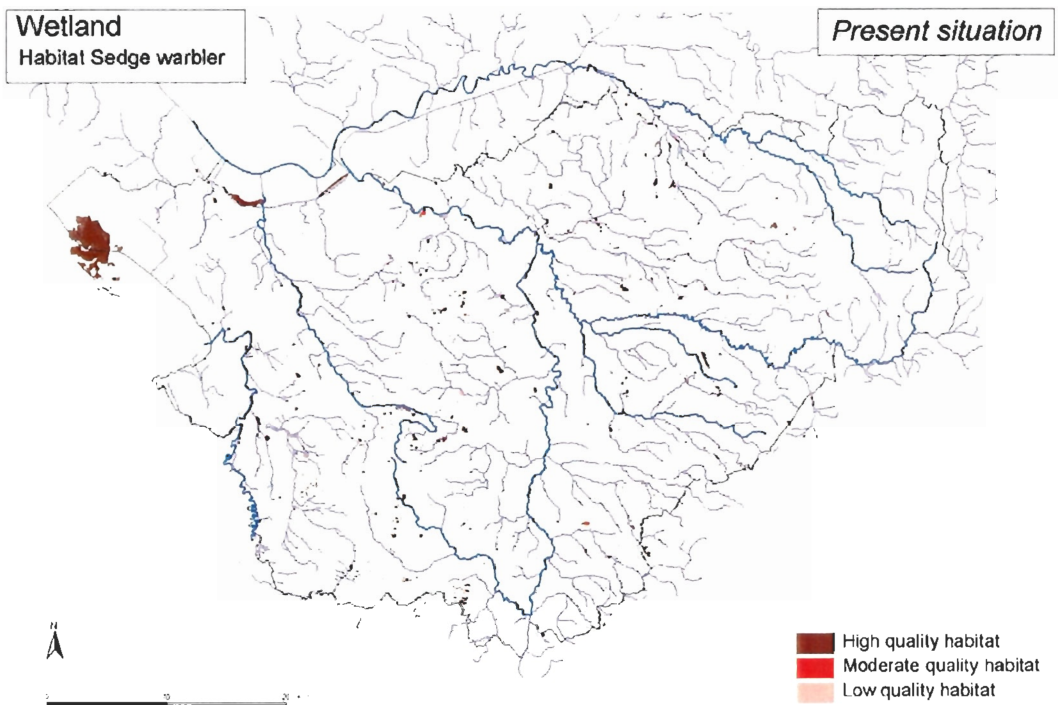


Figure 5 Suitable habitat for the Sedge warbler in the present situation

3.3.2 Ambition levels

A number of initiatives are and will be carried out for the restoration of river habitat. These measures will improve habitat quantity and quality.

Quantity improvement of habitat by:
- *Bank fenced*: to prevent cattle trampling the river edge so as to encourage the development of bankside vegetation for the benefit of otters, water voles, birds, etc.
- *6 m buffer around water bodies*: for same reason,
- *Altering management or land use* along water bodies (e.g. by Stewardship).

Quality improvement of wetland habitat by:
- *Advice*: offering a wide range of advice on pollution, angling, etc. with the aim of reducing silt erosion and deposition in rivers. The output will be reduced silt and nutrient input into rivers, clearer water, higher photosynthesis and improved fish spawning, invertebrate life, etc.

The ambition level for the ecological network is shown in Table 3.

Table 3 Ambition levels for rivers

Type of measure	Low ambition level	High ambition level
Quality of habitat		
Advice	1,500 km	3,000 km
Quantity of habitat		
Bank fenced and 6 m buffer	600 km	1,200 km
Potential wetland sites and stewardship	330 ha	2,400 ha

3.3.3 Decisions and assumptions

- The sites indicated as 'river valley floodplains', 'tidal flats and coastal floodplains', 'inland standing water' in the shapefile of ecoscapes, added with the sites in the shapefiles *'tidal_fp.shp'*, *'river_fp.shp'* and *'meres.shp'* reflect the potential wetland sites in Cheshire County.
- The sites indicated as 'mires' in Figure 2 ('meres and mires' from *ecoscape.shp* minus the sites from *meres.shp*) reflect the sites that may contribute to the ecological network for wetland areas.
- Conditions in wetland areas in the Pennines are so cold and extreme, that many lowland wetland species do not occur in this area. Connecting lowland and upland types of wetlands is therefore not a priority.
- The LARCH-analysis only generates information on the present location of wetland habitat in the lowland area. No information on wetland areas in the Pennines was available and attention was therefore focussed on networks in the low parts of Cheshire County.

3.4 Woodland

3.4.1 Present situation

A total of 1,977 ha of ancient woodland is present in the study area (Ancient Woodland Inventory; English Nature; Figure 6) of which 1,541 ha consist of semi-natural ancient woodland and 436 ha is replanted. The total area of all broad-leaved woodland is 5,100 ha (1984 Phase 1 Habitat Survey).

The OS Master Map shows 14,000 ha of land parcels that contain woodland but as they also include other habitat this is obviously an over estimation (Table 4).

Figure 6 shows that the woodland areas are small and scattered over almost all Cheshire County. The above mentioned data are the most accurate and up to date available for woodland habitat. Note that for the LARCH analysis of woodland different data from the shown datasets were used. As a result, some differences in the analysis of the present situation will occur.

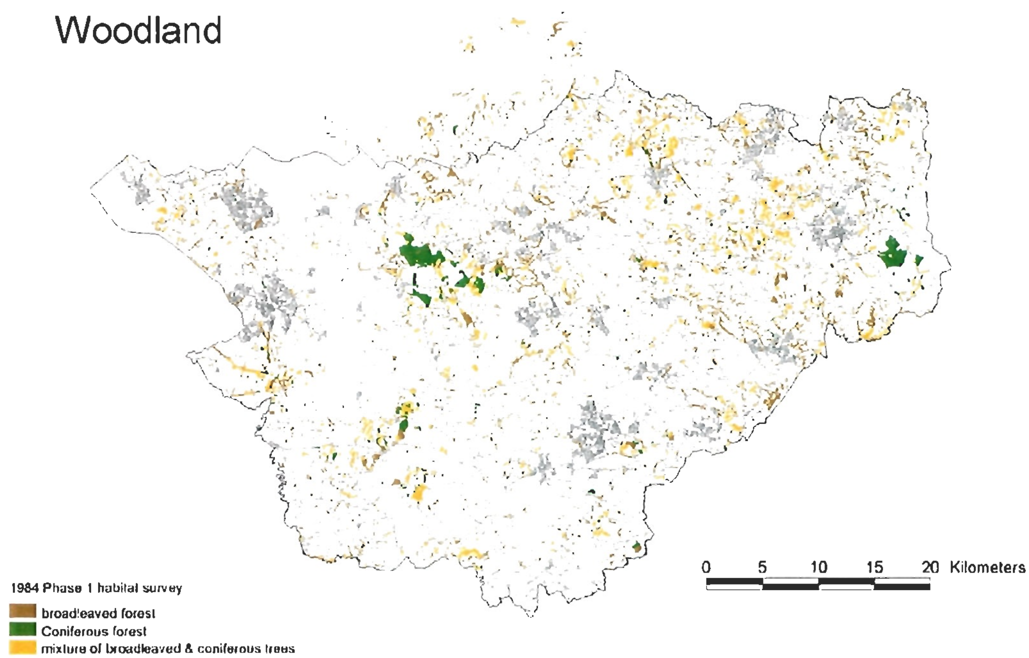


Figure 6 Actual woodland in Cheshire County (source: OS Master Map & 1984 Phase 1 Habitat Survey)

Table 4 Woodland area in Cheshire County that is mapped

Source	Vegetation type	Area (ha)
Ancient Woodland Inventory (English Nature)	Semi-natural existing ancient woodland (1,541 ha) Replanted (436 ha)	1,977
1984 Phase 1 Habitat Survey	Broad-leaved woodland	5,100
OS Master Map	Land parcels that contain woodland (overestimate)	14,000

3.4.2 Ambition levels

The present increase in woodland area is equivalent to a 5% increase over some decades. The low ambition level in this study is higher: an increase of 1,250 ha woodland. The high ambition level is set at an increase of 2,500 ha extra woodland.

3.4.3 Decisions and assumptions

- The expansion of woodland that is aimed for in the ambition levels can be realised anywhere in the county (but we would not want to plant new woodland on existing features of high value for nature conservation).
- Sites that are referred to as 'ancient woodland' in the Ancient woodland inventory are considered to be high quality habitat for woodland species, and to accommodate specific species of ancient forests.

3.5 Grassland

3.5.1 Present situation

In 1996, some 3,000 ha of semi-improved and unimproved grassland sites were mapped in a Grassland Inventory of Cheshire (Figure 7; Table 5). These sites are situated randomly in the landscape: the presence of these more or less 'neglected' grasslands is more related to coincidental circumstances (traditional management by any farmer) than to features of the landscape (e.g. soil type;). The presence of actual improved grassland sites is shown on the land use map (Figure 7). Note that for the LARCH analysis of grassland species different data from the above mentioned datasets were used. As a result, some differences in the analysis of the present situation may occur.

Table 5 Area of rough grassland in Cheshire County in 1996

Source	Vegetation type	Area (ha)
Grassland Inventory	Semi-improved and unimproved grassland	3,000

3.5.2 Ambition levels

The minimum ambition level was set at 3,800 ha grassland and 500 km extra semi- or unimproved grass strips. The high ambition level was to develop 7,600 ha grassland and 1,000 km grass strips.

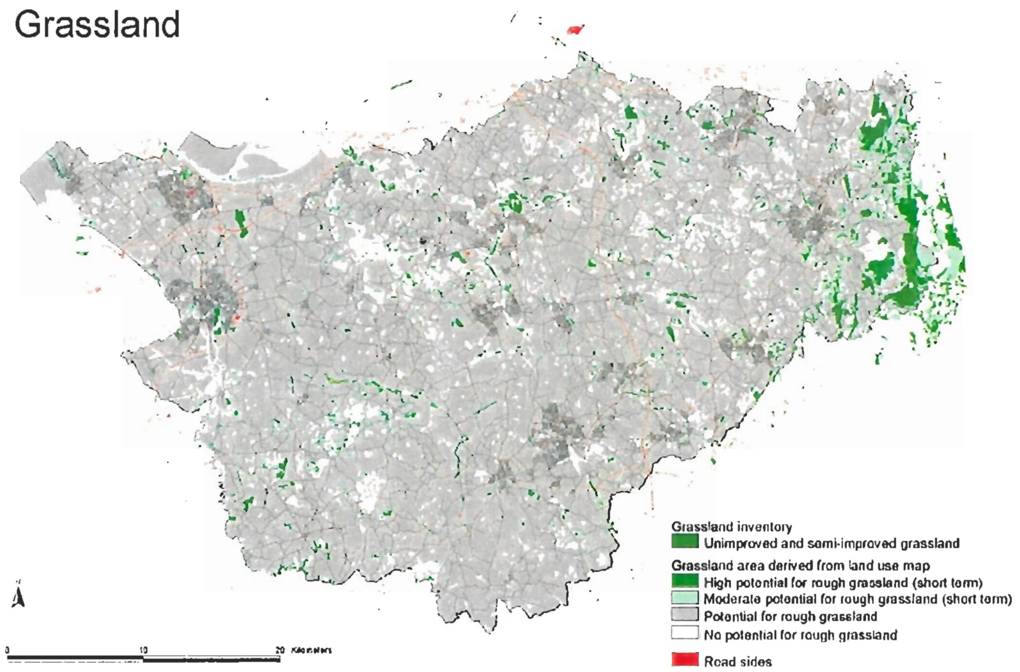


Figure 7 Presence of unimproved and semi-improved grassland (source: Grassland Inventory) and sites that have potential for rough grassland (after land use map and van der Sluis, 2003)

3.5.3 Decisions and assumptions

- The semi- and unimproved grassland sites, mapped in the Grassland Inventory, are considered to be high quality habitat for grassland species
- Grassland sites in the Pennines support different species than sites in the plains of Cheshire. It is not useful to try and connect these types of grasslands in an ecological network
- All land use and soil types are suitable for the development/restoration of unimproved grassland, except the land use types 'open water' and 'habitation', and transformation of woodland into rough grassland is considered to be undesirable
- Transformation of sites with improved grassland takes less effort and time than transformation of other land use types. For transformation into natural grassland types these improved grassland sites are considered first choice.

4 Step 1: Selection of ecosystem networks

The following ecosystems that occur in Cheshire County were selected:

- Meres and mosses
- Heathland
- Rivers
- Woodland
- Grassland

The order of the ecosystems indicates the priority that is given to the planning of sound ecological networks by the Chester ECOnet team.

Figure 8 gives an overview of the presence of these ecosystems and land use types in Cheshire County.

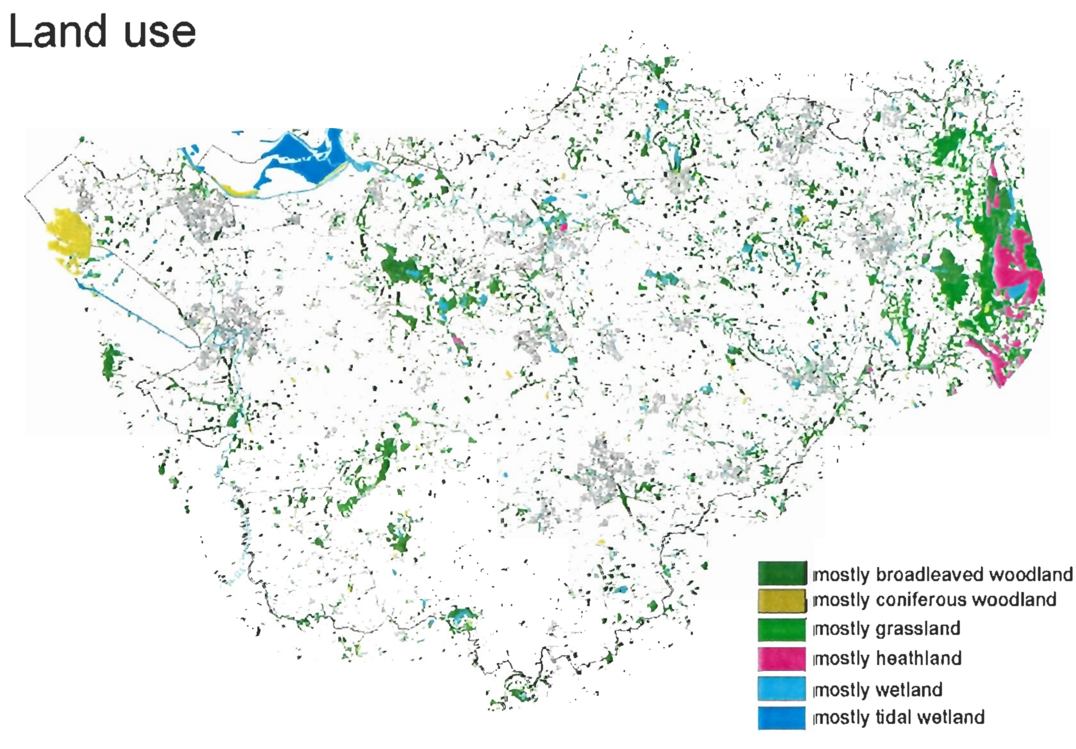


Figure 8 Overview of priority ecosystems and land use types in Cheshire County

5 Step 2: Selection of ecoprofiles

5.1 Meres and mosses

5.1.1 Overview on available ecoprofiles

Information for only a few specific species of meres and mosses was available (Table 6). The species included in Table 6 are all used in the LARCH analysis of the present situation (van der Sluis *et al.*, 2003).

Table 6 Traits of Ecological profiles of peatland species (after van der Sluis et al., 2003)
Printed italic: ecological profiles, used in the analysis of the present situation.
** = data originated from LARCH database*

Name ecological profile	Sensitive for barriers?	Max. distance between key areas (km)	Key area (ha/no. of patches)	Minimum width corridor	Maximum interruption corridor
Black darter	*No*	*50*	*5patches*		
Four-spotted chaser	*No*	*50*	*5patches*		
Green hairstreak	*No*	*5**	*100*		

5.1.2 Analysis of network quality in the present situation

The three species analysed for meres and mosses are Black darter, Green hairstreak and Four spotted chaser (van der Sluis *et al.*, 2003). The Green hairstreak has a limited dispersal range, whereas the Four spotted chaser and Black darter are very mobile.

Black darter
One key population is found in south Cheshire, elsewhere there are only small local populations. Since the habitat requirements are not large and the dispersal capacity is large (good connectivity), the small populations that remain still result in a sustainable population (Table 7).

Table 7 Results LARCH analysis Black darter (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Black Darter	Present situation
Population assessment	+
Network assessment	++
Connectivity	+++

Green hairstreak
Enough habitat is present for a minimal viable population (MVP in the Pennines and around Delamere Forest): some key populations are found further south. This results in a viable habitat network for this ecoprofile (Table 8).

Table 8 Results LARCH analysis Green hairstreak (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Green hairstreak	Present situation
Population assessment	++
Network assessment	+++
Connectivity	+

Four-spotted chaser
The spatial behaviour is similar to that of the Black darter and the results are very much the same. The Four-spotted chaser uses a wider range of habitats; the amount of habitat is therefore sufficient for a MVP. The long dispersal range results in a well-connected landscape for this species (Table 9).

Table 9 Results LARCH analysis Four-spotted chaser (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++= moderate – good; +++ = good - very good

Four spotted chaser	Present situation
Population assessment	++
Network assessment	+++
Connectivity	+++

5.1.3 Selection of target ecoprofiles

For the high ambition level, the ecoprofile 'Green hairstreak' is chosen as the most suitable target ecoprofile for meres and mosses. Species with this ecological profile are sufficiently mobile to be able to deal with a poor connectivity of habitat in the county, and an ecological network could largely improve the viability of populations of these kind of species.

Barriers in the landscape, as for example roads or railways, do not fragment the habitat of (flying) species that fit this ecoprofile. We have no knowledge of an ecoprofile with similar traits, but where the habitat is fragmented by barriers. Therefore, we took into account that species with similar traits might occur that do have problems crossing barriers.

5.2 Heathland

5.2.1 Overview on available ecoprofiles

Two types of lowland heathland are selected from Broekmeyer & Steingröver (2001):

- Dry heath
- Wet heath with fens

Both types are present in lowland Cheshire. Ecoprofiles for upland heathland are not available in Broekmeyer & Steingröver (2001).

Table 10 and Table 11 show the available ecoprofiles for lowland heathland and the ecoprofiles used to analyse the present situation with LARCH.

Table 10 Lowland heath: ecoprofiles not sensitive to barriers

Printed in black:	*ecoprofiles of dry heathland*
Printed in blue:	*ecoprofiles of wet heathland*
Printed in green:	*species that were used for the analysis of the present landscape*
Underlined:	*ecoprofile contains at least one species that could/does occur in Cheshire*
Background colour green:	*ecoprofiles with a very sustainable habitat network covering most suitable areas in the study area*
Background colour yellow:	*ecoprofiles with potential for sustainable habitat networks in parts of suitable areas in the study area*
Background colour red:	*ecoprofiles with no potential for a sustainable habitat network in the study area*
Black frame:	*selected target ecoprofile*

Dispersal capacity (km) / Key Area (ha)	0-3	3-7	7-15	15-25	25-35	>35
0-10						(least vulnerable for fragmentation)
10-100	Grizzled skipper	Grayling Small heath				
100-500						
500-1000				Stonechat	Wood lark Black grouse	
1000-5000						
> 5000	(Most vulnerable for fragmentation)					

Table 11 Lowland heat: ecoprofiles sensitive to barriers

Printed in black:	*ecoprofiles of dry heathland*
Printed in blue:	*ecoprofiles of wet heathland*
Printed in green:	*species that were used for the analysis of the present landscape*
Underlined:	*ecoprofile contains at least one species that could/ does occur in Cheshire*
Background colour green:	*ecoprofiles with a very sustainable habitat network covering most suitable areas in the study area*
Background colour yellow:	*ecoprofiles with potential for sustainable habitat networks in parts of suitable areas in the study area*
Background colour red:	*ecoprofiles with no potential for a sustainable habitat network in the study area*
Black frame:	*selected target ecoprofile*

Dispersal capacity (km) / Key Area (ha)	0-3	3-7	7-15	15-25	25-35	>35
0-10	Idas blue Alcon blue Silver-studded blue Palmate newt					(least vulnerable for fragmentation)
10-100	Smooth snake Moor frog Common lizard					
100-500	Viper					
500-1000						
1000-5000						
> 5000	(Most vulnerable for fragmentation)					

5.2.2 Analysis of network in present situation

The three species analysed for heathland are Stonechat, Small heath and Common lizard. The first two species have a limited dispersal range, whereas the Stonechat is more mobile (van der Sluis *et al.*, 2003). 'Stonechat' and 'Common lizard' represent species that occur in lowland heath. 'Small heath' represents the limited number of species that occur both in lowland and upland heath.

Stonechat

Based on the distribution of heathland in Cheshire this species could only occur in local populations (Table 12). In reality they occur mainly in dune areas along the coast, and in Wirral. As part of the Wirral area is missing in the habitat maps this area could not be taken into account. At present the network is not viable. Connectivity is also low, due to lack of habitat.

Table 12 Results LARCH analysis Stonechat (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Stonechat	Present situation
Population assessment	-
Network assessment	+
Connectivity	

Small heath
The only stable population is located in the Pennines. The remainder of Cheshire could contain small local populations. Due to their dispersal capacity (up to 5000 m), those areas might occasionally be occupied by small numbers of butterflies. The connectivity is limited, with the focal point obviously in the Pennines (Table 13).

Table 13 Results LARCH analysis Small heath (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Small heath	Present situation
Population assessment	+
Network assessment	+++
Connectivity	+

Common lizard
This ecoprofile is not viable under present conditions (Table 14). Roads fragment the habitat and the natural areas can only maintain small local populations. In the LARCH analysis without roads, viable populations are possible around Delamere Forest, further south towards Peckforton and in the Pennine foothills.

Table 14 Results LARCH analysis Common lizard (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Common lizard	Present situation
Population assessment	0
Network assessment	0
Connectivity	-

5.2.3 Remarks on the present situation: upland heath

Since most of Cheshire lies below the altitude of 250 m, the type of heath vegetation that occurs in most of the County is lowland heath.

In a relative small area of the County near the east boundary, upland heath is abundant. This upland heath or moorland is part of a larger area of actual and potential upland heath that is situated mainly across the border in the Peak Park. The area outside the county constitutes the 'body' of the habitat network of upland heath; the upland heath sites in Cheshire are situated at the very edge of this habitat network.

If habitat fragmentation is limiting for the biodiversity in upland heath, the task of creating a viable habitat network would mainly lie outside Cheshire County.

However, the landscape analysis with the ecoprofile 'Small heath' shows that both connectivity and amount of habitat area are very high in the Pennines (thanks to the large area of suitable habitat in neighbouring counties). To improve biodiversity for upland heathland, the task in Cheshire is to improve the *quality* of habitat in the Pennines. Lowering the grazing pressure by sheep can easily raise the quality of these sites. In general, expanding the area of high quality habitat in Cheshire will have a positive effect on biodiversity in the County. Wherever existing habitat quality is degraded, species will be able to recolonize such sites quite easily. However, these upgraded sites in Cheshire will only contribute little to the sustainability of the total, county exceeding habitat network of upland heath species.

5.2.4 Selection of target ecoprofiles

For lowland heathland, the ecoprofiles 'Common lizard' (representing barrier sensitive species) and 'Grayling' (representing species that are not sensitive to barriers) are selected (Table 10 and Table 11).

For upland heathland habitat fragmentation is not restricting biodiversity, and the task is to improve habitat quality. These sites are not prioritised, therefore, by means of an ecoprofile.

5.3 Rivers

5.3.1 Overview on available ecoprofiles

The selected ecoprofiles for rivers and floodplains are the ecoprofiles of 2 types of wetlands in Broekmeyer & Steingröver (2001):

- Brooks and brook forest
- Marsh, brushwood and large water

Both types are present in Cheshire.

The traits of these ecoprofiles are listed in Table 15. In Table 16 examples are shown of species which are represented by these ecoprofiles, and which of these species occur in the study area. An overview on the ecological traits of ecoprofiles are shown in Table 18 and Table 20).

Table 15 Traits of ecoprofiles of rivers and floodplains (after Broekmeyer & Steingröver, 2001 and van der Sluis, 2003). Italic: species used in the LARCH-analyses of the present situation

Eco profiles	**Sensitivity to barriers**	**Max. distance between key areas (km)**	**Key area (ha)**	**Minimum width corridor**	**Maximum gap width corridor**
Brook lamprey	yes	-	-	10	0
Stone loach	yes	-	-	10	0
Purple Emperor	yes	2	50	25	50
Lesser Marbled Fritillary	yes	2	5	25	50
Ide	yes	-	-	10	0
Beaver	yes	20	300	50	50
Bluethroat	no	10	300	-	-
Grasshopper Warbler	no	20	300		
Large Copper	no	5	50	-	-
Spined loach	yes	-	-	25	0
Wels	yes	-	-	50	0
Root vole	yes	5	50	25	50
Otter	yes	50	-	50	50
Lesser Marbled Fritillary	yes	0.5	5	70	10
Sedge Warbler	no	11	55	-	-
Grass snake	yes	11	300	25	25
Bittern	no	30	750	-	-
Sunbleak	yes	-	-	25	0
Banded demoiselle	*No*	*10*	*10*	*10*	
Sedge warbler	*No*	*10*	*100*	-	-
Water vole	*Yes*	*3.2*	*25*		

Table 16 List of ecoprofiles of rivers and floddplains (Broekmeyer & Steingröver, 2001) and examples of species they represent. Underlined: species that occur in Cheshire County

Name ecoprofile	**Representing species e.g.**
Brook lamprey	Brook lamprey
Stone loach	Stone loach
Purple Emperor	Purple Emperor
Lesser Marbled Fritillary	Lesser Marbled Fritillary <u>European Harvest Mouse</u>
Ide	Ide
Beaver	Beaver
Bluethroat	Bluethroat
Great Reed Warbler	Great Reed Warbler <u>Grasshopper Warbler</u>
Large Copper	Large Copper
Spined loach	Spined loach
Wels	Wels
Root vole	Root vole
<u>Otter</u>	<u>Otter</u>
Lesser Marbled Fritillary	Lesser Marbled Fritillary
<u>Sedge Warbler</u>	<u>Sedge Warbler</u>
<u>Grass snake</u>	<u>Grass snake</u>
Bittern	Bittern

Table 17 Rivers and floodplains: ecoprofiles not sensitive to barriers

Printed in black:	*ecoprofiles of rivers and their floodplains*
Printed in green:	*species that were used for the analysis of the present landscape*
Underlined:	*ecoprofile contains at least one species that could/does occur in Cheshire*
Background colour green:	*ecoprofiles with a very sustainable habitat network covering most suitable areas in the study area*
Background colour yellow:	*ecoprofiles with potential for sustainable habitat networks in parts of suitable areas in the study area*
Background colour red:	*ecoprofiles with no potential for a sustainable habitat network in the study area*
Black frame:	*selected target ecoprofile*

Dispersal capacity (km) Key Area (ha)	**0-3**	**3-7**	**7-15**	**15-25**	**25-35**	**>35**
0-10			Banded demoiselle			**(least vulnerable to fragmentation)**
10-100			Sedge Warbler			
100-500			Bluethroat	Great reed warbler		
500-1000					Bittern	
1000-5000						
> 5000	**(Most vulnerable to fragmentation)**					

Table 18 Rivers and floodplains: ecoprofiles sensitive to barriers

Printed in black:	*ecoprofiles of rivers and their floodplains*
Printed in green:	*species that were used for the analysis of the present landscape*
Underlined:	*ecoprofile contains at least one species that could/does occur in Cheshire*
Background colour green:	*ecoprofiles with a very sustainable habitat network covering most suitable areas in the study area*
Background colour yellow:	*ecoprofiles with potential for sustainable habitat networks in parts of suitable areas in the study area*
Background colour red:	*ecoprofiles with no potential for a sustainable habitat network in the study area*
Black frame:	*selected target ecoprofile*

Dispersal capacity (km) / Key Area (ha)	**0-3**	**3-7**	**7-15**	**15-25**	**25-35**	**>35**
0-10	Lesser marbled fritillary	Root vole				**(Least vulnerable to fragmentation)**
10-100		Water vole				
100-500			Grass snake	Beaver		
500-1000						
1000-5000						
> 5000	**(Most vulnerable to fragmentation)**					Otter

5.3.2 Analysis of network quality in the present situation

(after: van der Sluis *et al.*, 2003.)

Banded demoiselle

Over 150 local populations constitute together a large viable network. The centre point of the population lies in the west, where main rivers flow (Table 19).

Table 19 Results LARCH analysis Banded demoiselle (source: van der Sluis et al., 2003)

- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Banded demoiselle	**Present situation**
Population assessment	++
Network assessment	+++
Connectivity	+++

Water vole
Only three local populations in Cheshire are large enough for a viable population and many patches are even too small for a local population. The network analysis shows that local populations and small patches together are part of a larger network which could potentially be very viable (Table 20). This is only true under the assumption that roads form barriers to the water vole. This is probably a correct assumption since in many cases rivers or ditches might be crossing roads, so fragmentation will be less than expected.

Table 20 Results LARCH analysis Watervole (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good very good

Water vole	Present situation
Population assessment	+
Network assessment	+++
Connectivity	-

Sedge warbler
Only a few areas are large enough to sustain a local population. The amount of habitat seems to be limiting for this species. Due to the large dispersal distance, however, the smaller areas link up to viable networks. The spatial cohesion of the landscape is presently sufficient for this species (Table 21).

Table 21 Results LARCH analysis Sedge warbler (source: van derSluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Sedge warbler	Present situation
Population assessment	+
Network assessment	++
Connectivity	+

5.3.3 Selection of target ecoprofiles

The target ecoprofiles, 'Sedge warbler' for flying species, and 'Water vole' for non-flying species were selected.

5.4 Woodland

5.4.1 Overview on available ecoprofiles

Four types of woodland vegetation were selected from the study by Broekmeyer & Steingröver (2001):
- Brook forest
- Forest, shrubbery and edge vegetation on clay
- Forest, shrubbery and edge vegetation on clay with large water
- Forest of poor and (fairly) rich sandy soil

These woodland types are present in Cheshire.

Table 22 shows the ecoprofiles that match the four selected vegetation types of woodland habitat. Examples are also shown of species they represent (Table 23).
An overview on the traits of ecoprofiles are shown in Table 24 and Table 25.

Table 22 Traits of ecoprofiles of woodland vegetation (after Broekmeyer & Steingröver, 2001)
Italic: species used in the LARCH-analyses of the present situation (van der Sluis et al., 2003).

Ecoprofiles	Data on dispersal capacity and area requirements			Requirements corridor		
	Dispersal distance (km)	Area key area (ha)	Sensitivity to barriers	Area stepping stone (ha)	Minimum width (m)	Maximum gap width (m)
Beaver	20	300	Yes	30	50	50
Nuthatch	11	50	No	5.5	-	-
Pine marten	30	3000	Yes	3000	100	100
European harvest mouse	2	5	Yes	1	25	50
Red deer	50	3000	Yes	300	1000	100
Squirrel	5	50	Yes	5.5	25	50
Marsh tit	11	300	No	30	-	-
Green woodpecker	20	750	No	75	-	-
Purple emperor	5	50	No	5.5	-	-
Slow worm	2	50	Yes	5.5	25	50
Silver-washed fritillary	5	50	No	5.5	-	-
Brown hairstreak	2	50	Yes	5.5	25	50
Water shrew	2	5	Yes	1	25	50
Dormouse	1.5	100	Yes			
Purple hairstreak	2	50	No			

Table 23 List of woodland ecoprofiles (Broekmeyer & Steingröver, 2001) and examples of species they represent
Underlined: species that occur in Cheshire County

Name ecoprofile	Representing species e.g.
Beaver	Beaver
Nuthatch	Nuthatch
Pine marten	Pine marten
European harvest mouse	European harvest mouse Bicolored shrew
Red deer	Red deer
Squirrel	Squirrel
Marsh tit	Marsh tit Pied flycatcher Fire crest
Green woodpecker	Green woodpecker
Purple emperor	Purple emperor
Slow worm	Slow worm
Silver-washed fritillary	Silver-washed fritillary
Brown hairstreak	Brown hairstreak
Water shrew	Water shrew European harvest mouse

Table 24 Woodland: ecoprofiles not sensitive to barriers

Printed in black:	*ecoprofiles of woodland*
Printed in green:	*species that were used for the analysis of the present landscape*
Underlined:	*ecoprofile contains at least one species that could/ does occur in Cheshire*
Background colour green:	*ecoprofiles with a very sustainable habitat network covering most suitable areas in the study area*
Background colour yellow:	*ecoprofiles with potential for sustainable habitat networks in parts of suitable areas in the study area*
Background colour red:	*ecoprofiles with no potential for a sustainable habitat network in the study area*
Black frame:	*selected target ecoprofile*

Dispersal capacity (km) / **Key Area (ha)**	**0-3**	**3-7**	**7-15**	**15-25**	**25-35**	**>35**
0-10	**Purple hairstreak**					**(least vulnerable** for fragmentation)
10-100	Brown hairstreak	Nuthatch Purple emperor Silver washed fritillary				
100-500			Marsh tit			
500-1000				Green woodpecker		
1000-5000						
> 5000	**(Most vulnerable for fragmentation)**					

Table 25 Woodland: ecoprofiles sensitive to barriers

Printed in black:	*ecoprofiles of woodland*
Printed in green:	*species that were used for the analysis of the present landscape*
Underlined:	*ecoprofile contains at least one species that could/does occur in Cheshire*
Background colour green:	*ecoprofiles with a very sustainable habitat network covering most suitable areas in the study area*
Background colour yellow:	*ecoprofiles with potential for sustainable habitat networks in parts of suitable areas in the study area*
Background colour red:	*ecoprofiles with no potential for a sustainable habitat network in the study area*
Black frame:	*selected target ecoprofile*

Dispersal capacity (km) Key Area (ha)	0-3	3-7	7-15	15-25	25-35	>35
0-10	European Harvest Mouse European Watershrew					(least vulnerable for fragmentation)
10-100	Dormouse Slow worm	Squirrel				
100-500				Beaver		
500-1000						
1000-5000					Pine marten	Red deer
> 5000	(Most vulnerable for fragmentation)					

5.4.2 Analysis of network in present situation

(after: van der Sluis *et al.*, 2003)

Purple hairstreak

Under the present conditions the species is able to form Minimum Viable Populations (MVPs) and several key populations in different places in the County. The network population is viable, partly due to the low habitat requirements of this butterfly.

Connectivity is limiting as a result of the low dispersal distance of the species (Table 26). This might well be an underestimation, however, since the species is likely to use hedges and woodrows for migration, which were not mapped in the OS MasterMap.

Table 26 Results LARCH analysis Purple hairstreak (source: van derSluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Purple hairstreak	Present situation
Population assessment	++
Network assessment	+++
Connectivity	+

Dormouse
Under the present conditions only one area, Delamere Forest, might be considered large enough for a key population (some 340 ha). However, as Delamere forest is essentially coniferous plantation, it is unsuitable for small woodland mammals that need broadleaved woodland. If barriers are considered to be of no importance, however, many woodland areas might be suitable for this species (Table 27). Roads in Cheshire cause considerable fragmentation, however, and most surviving woodlands are too small since the species requires larger, old growth forests. This might be an underestimation, since hedgerows are not mapped, and more areas might be connected.

Table 27 Results LARCH analysis Dormouse (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Dormouse	Present situation
Population assessment	+
Network assessment	0
Connectivity	-

Nuthatch
The Nuthatch could potentially live in most wooded parts of the County. Due to its large home range, the species can be considered very viable (Table 28). The fact that the species is recently expanding into Cheshire, illustrates that landscape connectivity for a small forest bird with a large home range might be adequate.

Table 28 Results LARCH analysis Nuthatch (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate - good; +++ = good - very good

Nuthatch	Present situation
Population assessment	++
Network assessment	+++
Connectivity	+++

5.4.3 Selection of target ecoprofiles

The quality of the habitat network for the selected ecoprofiles was evaluated, based on the LARCH-results, i.e. spatial requirements of ecoprofiles and analysis of the present landscape. The area and distribution of woodland sites suggest that sustainable habitat networks are possible for ecoprofiles that are not sensitive to fragmentation or ecoprofiles that have small area requirements (Table 26 and Table 28, green background). For some ecoprofiles, however, the woodland patches offer little possibilities for long-term survival and a viable network can only be achieved by taking additional measures (Table 26 and Table 28, yellow background). The 'Marsh tit" ecoprofile is selected as target ecoprofile for flying species. For non-flying species the ecoprofile "Dormouse" is selected. For these target ecoprofiles spatial options for an improved ecological network will be generated.

5.5 Grassland

5.5.1 Overview on available ecoprofiles

Two types of grassland are selected from Broekmeyer & Steingröver (2001):

- Grassland
- Grassland with small water

Table 29 shows the ecoprofiles that match the selected vegetation types of grassland habitat. Examples of species they represent are also shown (Table 30). An overview of the traits of ecoprofiles are shown in Table 31 and Table 32).

Available ecoprofiles are based on species that occur mainly in the plains of Cheshire County and not in the Pennines. These ecoprofiles were used to analyse lowland grasslands and design spatial options. For upland grasslands, no suitable information is available, and therefore no advice can be given.

Table 29 Traits of ecoprofiles of grassland vegetation (after Broekmeyer & Steingröver, 2001)
Italic: species used in the LARCH-analyses of the present situation (van der Sluis et al., 2003).

Ecoprofiles	**Sensitivity to barriers**	**Max. distance between key areas (km)**	**Key area (ha)**	**Minimum width corridor**	**Maximum gap width (m)**
Dingy skipper	yes	2	50	25	50
	yes	-	-	10	0
Dusky Large Blue	yes	0.5	5	70	50
European Harvest Mouse	yes	2	5	25	50
Mazarine Blue	no	5	50	-	-
Root vole	yes	5	50	25	50
Pool frog	yes	2	50	25	50
Small Pearl-bordered Fritillary	yes	2	5	25	50
Great crested newt	*yes*	*1*	*3,3*	*70*	*10*
Barn owl	*no*	*50*	*2000*	-	-
Common blue	*yes*	*0.3*	*20*		

Table 30 List of ecoprofiles of rough grassland (Broekmeyer & Steingröver, 2001) and examples of species they represent. Underlined are species that occur in Cheshire County

Name ecoprofile	Representing species e.g.
Dingy Skipper	Sooty Copper Dark Green Fritillary Purple-edged Copper Glanville Fritillary
Dusky Large Blue	Dusky Large Blue Marsh Fritillary
European Harvest Mouse	European Harvest Mouse Common Mole
Mazarine Blue	Mazarine Blue Large Copper Grayling
Root vole	Root vole
Pool frog	Pool frog Tree Frog Spadefoot toad Natterjack toad
Small Pearl-bordered Fritillary	Small Pearl-bordered Fritillary Small Skipper Pearly Heath

Table 31 Grassland: ecoprofiles not sensitive to barriers

Printed in black:	*ecoprofiles of grassland*
Printed in green:	*species that were used for the analysis of the present landscape*
Underlined:	*ecoprofile contains at least one species that could/ does occur in Cheshire*
Background colour green:	*ecoprofiles with a very sustainable habitat network covering most suitable areas in the study area*
Background colour yellow:	*ecoprofiles with potential for sustainable habitat networks in parts of suitable areas in the study area*
Background colour red:	*ecoprofiles with no potential for a sustainable habitat network in the study area*
Black frame:	*selected target ecoprofile*

Dispersal capacity (km) Key Area (ha)	0-3	3-7	7-15	15-25	25-35	>35
0-10		Mazarine blue				(Least vulnerable for fragmentation)
10-100						
100-500						
500-1000						
1000-5000						Barn owl
> 5000	(Most vulnerable for fragmentation)					

Table 32 Grassland: ecoprofiles sensitive to barriers

Printed in black:	*ecoprofiles of grassland*
Printed in green:	*species that were used for the analysis of the present landscape*
Underlined:	*ecoprofile contains at least one species that could/ does occur in Cheshire*
Background colour green:	*ecoprofiles with a very sustainable habitat network covering most suitable areas in the study area*
Background colour yellow:	*ecoprofiles with potential for sustainable habitat networks in parts of suitable areas in the study area*
Background colour red:	*ecoprofiles with no potential for a sustainable habitat network in the study area*
Black frame:	*selected target ecoprofile*

Dispersal capacity (km) **Key Area (ha)**	**0-3**	**3-7**	**7-15**	**15-25**	**25-35**	**>35**
0-10	Dusky Large blue European harvest mouse Small Pearl-bordered fritillary Great crested newt					**(Least vulnerable for fragmentation)**
10-100	Dingy skipper Pool frog Common blue	Root vole				
100-500						
500-1000						
1000-5000						
> 5000	(Most vulnerable for fragmentation)					

5.5.2 Analysis of network in the present situation
(after: van der Sluis *et al.*, 2003)

The three species analysed for grassland ecosystems are *Great crested newt*, *Barn owl* and *Common blue*. The Great crested newt and Common blue have a limited dispersal range, the Barn owl however is a medium sized bird, which can be very mobile. All of the species occur in the plains of Cheshire County.

Great crested newt
Because of the large number of ponds in Cheshire County, several viable networks of ponds were found. In reality the situation might be even better in some areas, since only open, non-vegetated ponds were used in the analysis (Table 33).

Table 33 Results LARCH analysis Great crested newt (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Great crested newt	**Present situation**
Population assessment	++
Network assessment	++
Connectivity	

Barn owl
In the present situation, all habitat is part of a large County wide network due to the large dispersal distance of this bird. No key area or viable population is present in the study area itself.

Table 34 Results LARCH analysis Barn owl (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Barn owl	**Present situation**
Population assessment	+
Network assessment	+++
Connectivity	++

Common blue
Potential MVPs are present in Delamere Forest and on the sandstone ridge. Several key populations and many small populations were found to be present. The network is partly sustainable, in particular in areas with MVPs or key areas. Since the dispersal distance is limited, most areas are not part of a larger network (Table 39).

Table 35 Results LARCH analysis Common blue (source: van der Sluis et al., 2003)
- = very poor – poor; + = poor – moderate; ++ = moderate – good; +++ = good - very good

Common blue	**Present situation**
Population assessment	+
Network assessment	+
Connectivity	++

5.5.3 Selection of target ecoprofiles

Target ecoprofiles that are useful for designing an ecological network for grassland species are the Common blue and the Barn owl (respectively sensitive and non-sensitive to barriers, Table 31 and Table 32). With the chosen ambition levels, the potential for viable populations for species they represent can be enlarged significantly.

The Barn owl represents birds with extensive territories, foraging in rough grassland. Nesting habitat is presumed to be sufficiently available all over the county (farms, old houses, cavities in trees). Characteristics of these ecoprofiles are derived from habitat description and historic data on their presence in Cheshire County (van der Sluis *et al.*, 2003).

6 Step 3: Generating spatial options

6.1 Meres and mosses

For meres and mosses, the target ecoprofile 'Green hairstreak' was selected. The spatial requirement of this ecoprofile is presented in Table 36.

Table 36 Spatial requirements for key area or viable populations of species represented by the ecoprofile 'Green hairstreak'

Ecoprofile Green hairstreak	
Key area	100 ha
Viable network, including key area	250 ha
Viable network, no key area	250 ha

6.1.1 Generating spatial options

Choices on county level

As a start, the (potential) habitat sites are clustered into (potential) habitat networks, based on the spatial characteristic of the target ecoprofile 'Green hairstreak' (Figure 9).

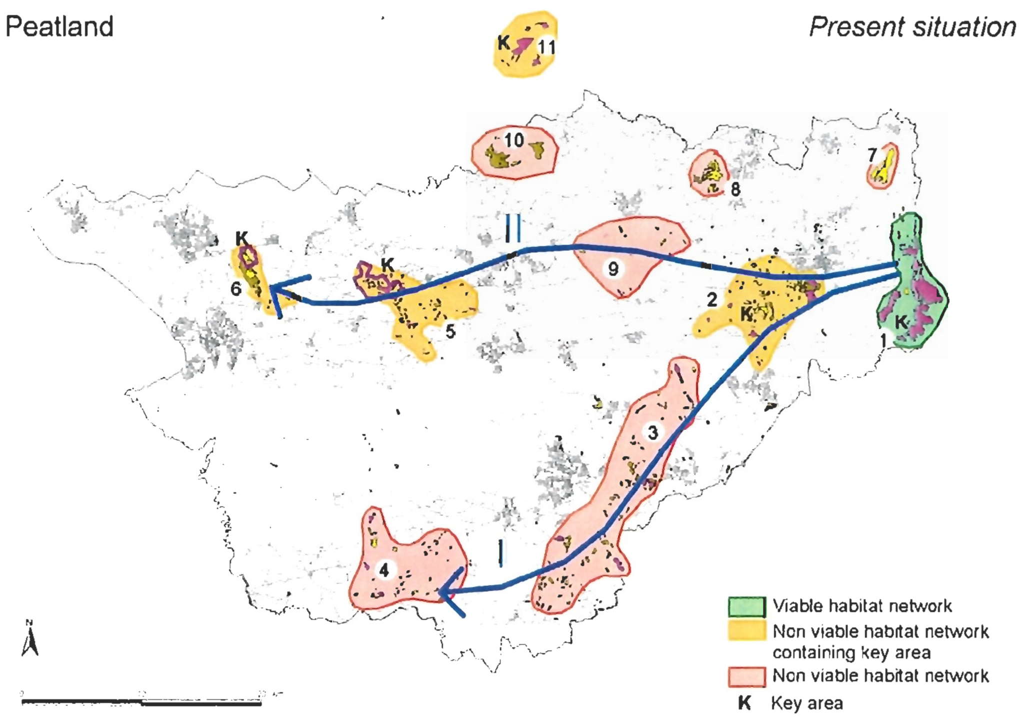


Figure 9 Clustering of (potential) habitat sites into (potential) networks, based on the ecological traits of the ecoprofile 'Green hairstreak'

In the east of the county in the Pennines, a local viable habitat network is present (Figure 9, nr. 1). Furthermore, three habitat networks contain key areas (nrs. 2, 5 and 6) but have insufficient supplementary habitat for a viable habitat network. The other habitat networks (nrs. 3,4,7,8,9 and 10) are too small and do not contain large enough sites to form a key area or viable network.

To design a viable habitat network in Cheshire County, it seems ecologically profitable to include the Pennines in this habitat network. The area contains vast amounts of peatland habitat and biodiversity will have declined least as a result of habitat fragmentation. From this refuge area, individuals can recolonize other habitat patches if a sound ecological network is created. Connecting isolated habitat patches or small isolated habitat networks to the viable habitat network in the Pennines will result in a strong increase in potential for a diversity of species.

The viable habitat network in the Pennines (nr. 1) can be connnected to other habitat networks along two axes (Figure 9):
- To the south-west, connecting numbers 1, 2, 3 and 4 (axis I),
- To the west, connecting numbers 1, 2, 9, 5 and 6 (axis II).

At first glance, it seems profitable to connect network numbers 2, 5 and 6 as these all contain key areas along axis II. Considering the dispersal capacity of 'Green hairstreak' ecoprofile (5 km), however, and the nature of the intermediate area (nr 9, in which peatland blocks are absent), it is not possible to connect these habitat clusters.

Connecting habitat networks along axis I, however, is possible. In between the present habitat clusters, sufficient sites are present where peatland vegetation can be restored. As a result, the nonviable isolated networks can be connected to the viable network in the Pennines. This option is highly profitable for biodiversity in peatland sites, in particular those outside the Pennines. A habitat network along axis I can even provide a link southwards with the network in the neighbouring county of Shropshire.

The realisation of an ecological network along axis I requires the restoration of peatland sites in network 2, so that networks 1, 2 and 3 can be connected. If this crucial restoration of peatland sites in network 2 is not possible, the idea of creating one large network connected to the viable network of the Pennines has to be abandoned. In the event that the habitat in network 2 can be sufficiently enlarged and condensed, then network 3 becomes crucial. Furthermore, investing in the restoration of network 4 is only profitable if network 2 and 3 are restored.

A third option is the random creation of isolated viable habitat networks. Habitat clusters 3, 7 and 10 are surrounded by sufficient meres and mosses that can be restored to give room for viable populations for species such as the Green hairstreak. Other habitat clusters seem only to have potential for small, non-sustainable habitat networks.

6.1.2 Ecological ranking of spatial options

As stated in 6.1.1 the greatest ecological profit is obtained by the restoration of meres and mosses in network 2. Restoring peatland sites in such a way that network 2 is connected to networks 1 and 3 has the highest priority. Depending on the possibilities for enlarging and condensing network 2; two strategies can be followed (Figure 10).

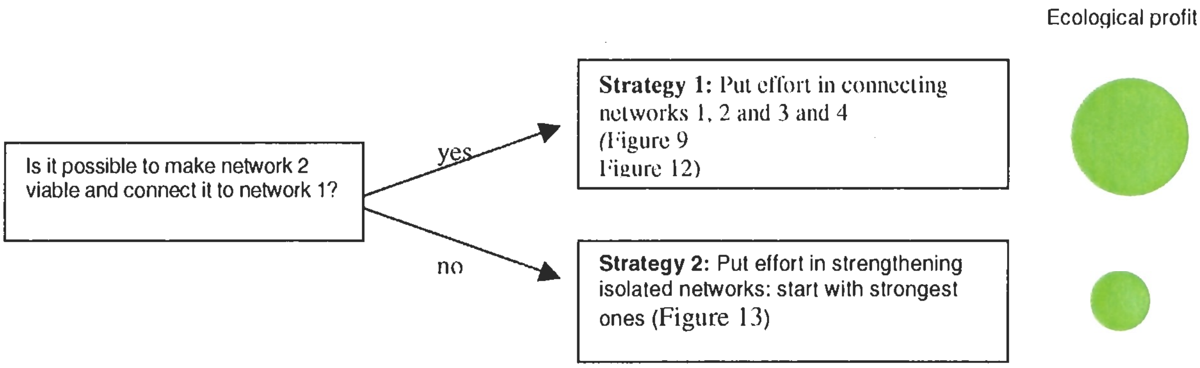


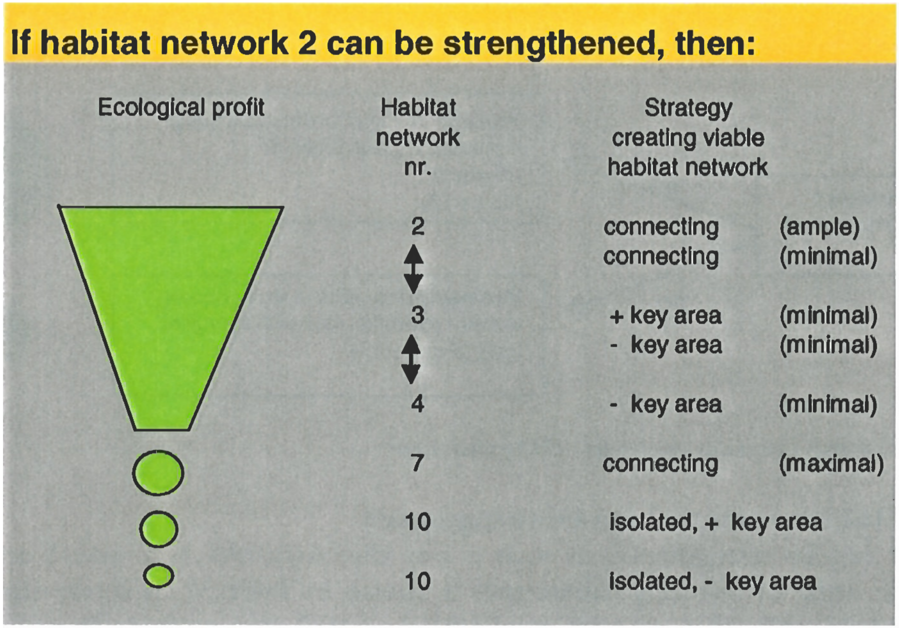
Figure 10 Spatial strategies for viable populations valid for most species

Strategy 1: if habitat network 2 can be strengthened
If network 2 can be strengthened in such a way that networks 1, 2 and 3 are connected, the order of restoring habitat sites is shown in Table 37. It shows that restoring peatland sites that connect networks 1 and 2 are ecologically most profitable (Figure 9; see also Figure 12). The minimum area needed to connect these networks is about 25 ha on individual specific locations (Figure 12, option 1). Option 2 is restoring sites that contribute to the density of habitat in between networks 1 and 3. Restoring any other peatland sites in network 2 is highly profitable because they may be (re)colonised by individuals from the Pennines network (nr.1).

The same strategy is valid for networks 3 and 4. In network 3 a viable network can be created with or without a key area. A viable network containing a key area is always preferable because it offers better spatial conditions for many species, especially those with smaller dispersal capacities or larger habitat requirements compared to the 'Green hairstreak' ecoprofile. Species that have trouble crossing barriers also profit more from key areas compared to many small habitat patches.

Table 37 Priority order of restoration of peatland sites according to strategy 1. The size of the green shapes indicates the ecological profit. Habitat networks that are not mentioned have no potential for creating a viable habitat network for the ecoprofile 'Green hairstreak'

ample	= *restoring sites with semi-natural vegetation that contribute to the connection with neighbouring networks or to a sustainable isolated network*
minimal option	= *restoring just enough sites for a sustainable network or connection with neighbouring sites (preferably sites with semi-natural vegetation are added)*



If habitat network 2 can be strengthened, then:

Ecological profit	Habitat network nr.	Strategy creating viable habitat network	
	2	connecting	(ample)
		connecting	(minimal)
	3	+ key area	(minimal)
		- key area	(minimal)
	4	- key area	(minimal)
	7	connecting	(maximal)
	10	isolated, + key area	
	10	isolated, - key area	

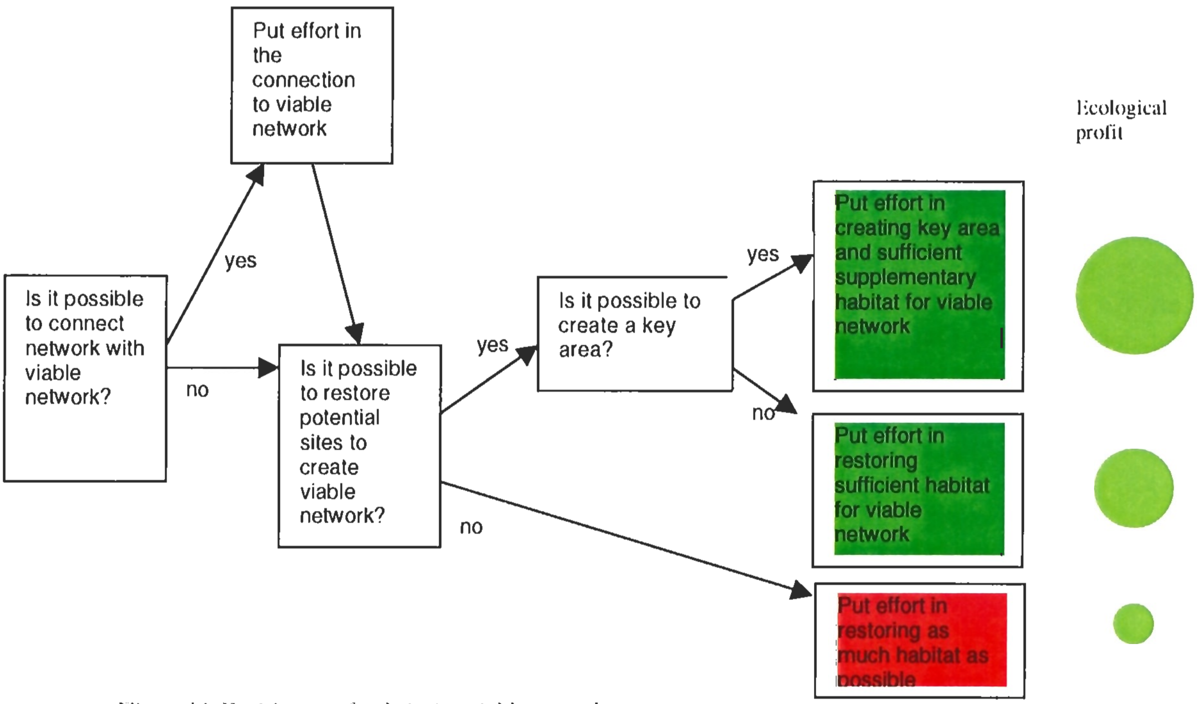


Figure 11 Decision tree for designing viable networks

After restoring peatland sites in network 2, 3 and 4, the next option is to restore habitat in isolated networks that are potential viable networks. Restoring habitat in network 7 and 8 can be profitable, therefore, because these areas may profit from (re)colonisation by individuals from network 1. Network 10 has enough potential sites to create a viable habitat network, but the chances of recolonisation of individuals are lower because of the cluster's relative isolation.

Habitat networks that have no potential for creating a viable habitat network are not included in Table 37.

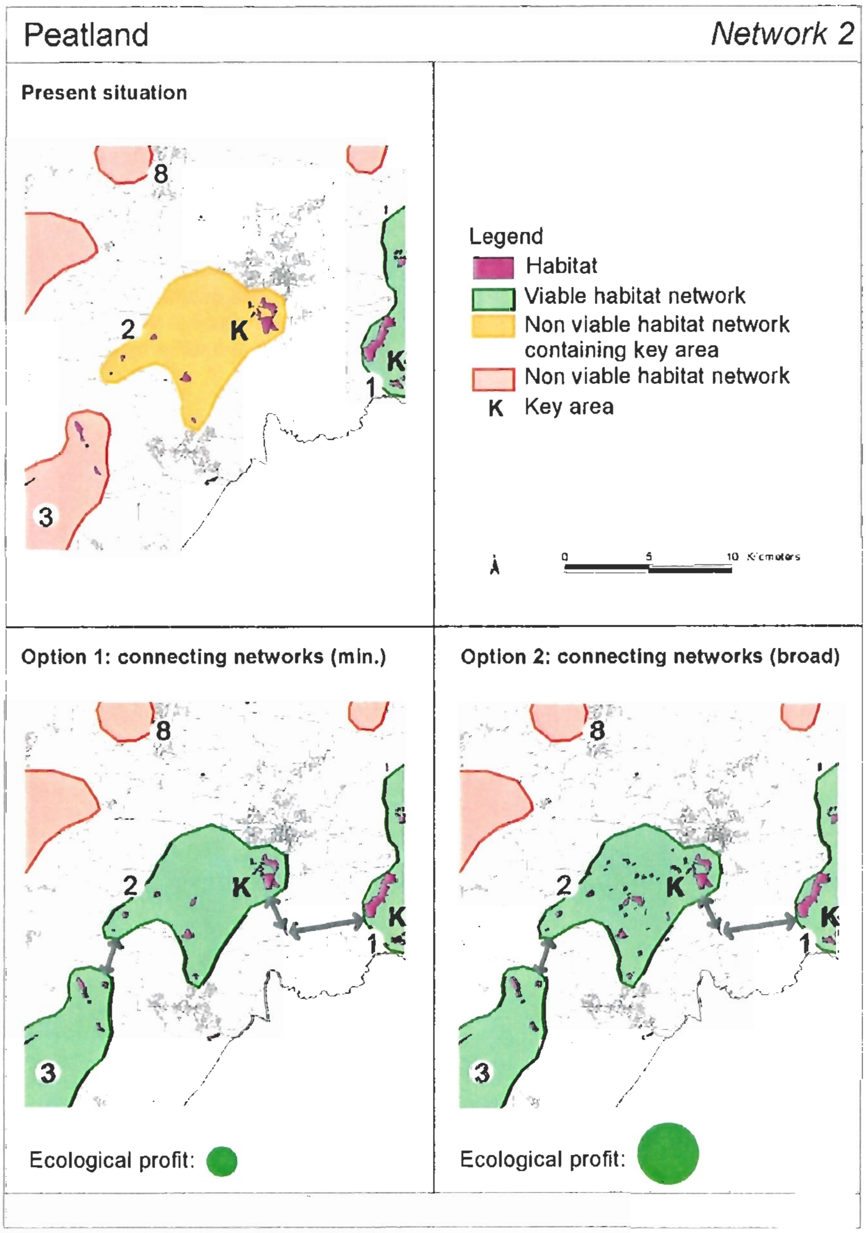


Figure 12 Spatial options for a viable habitat network for peatland sites in network 2

Strategy 2: if habitat network 2 cannot be strengthened
In this case creating a large countywide ecological network for species with the ecological profile of 'Green hairstreak' is not possible. The best alternative option is to make viable as many habitat networks as possible, although these networks are often isolated (Table 38).

The possibilities for creating different isolated, viable networks with or without a key area are illustrated for Network 3 in Figure 13.

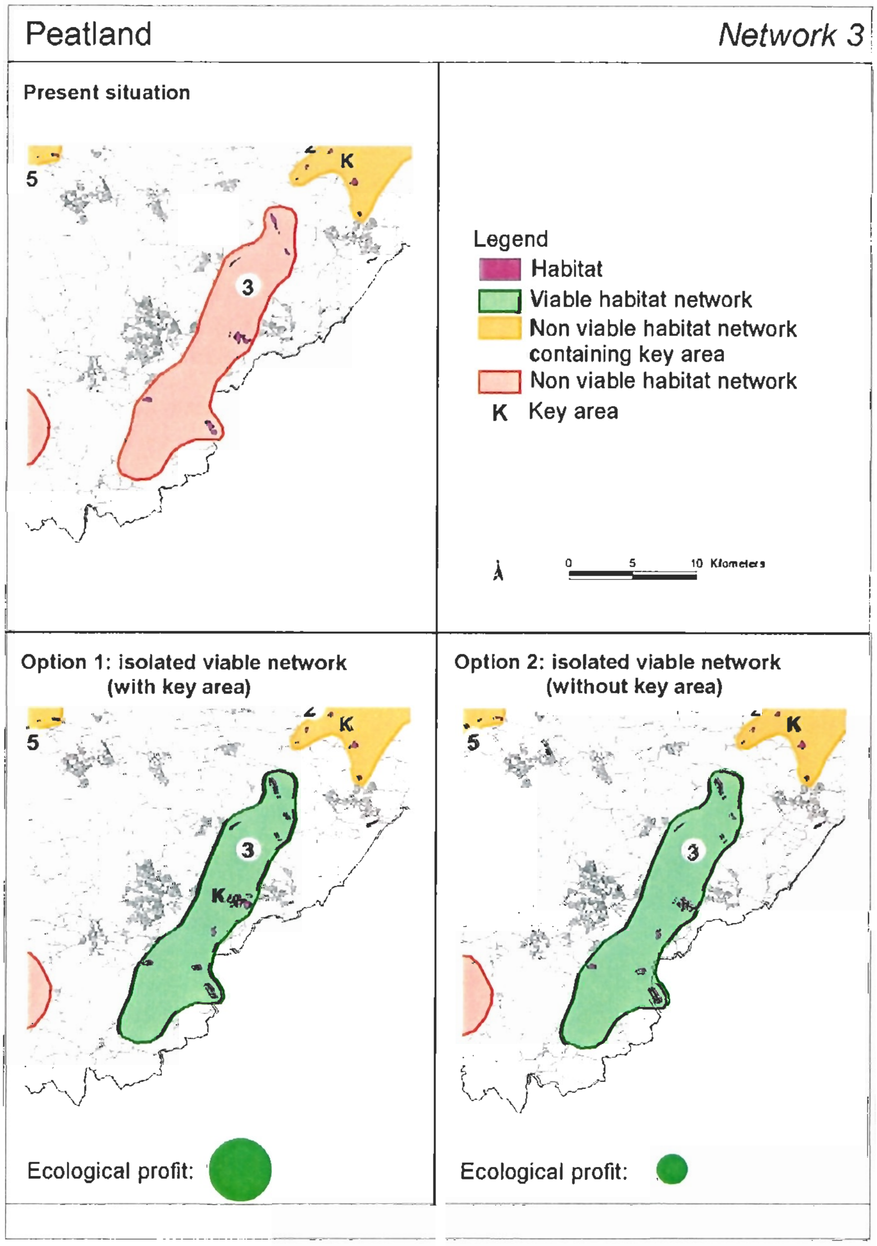
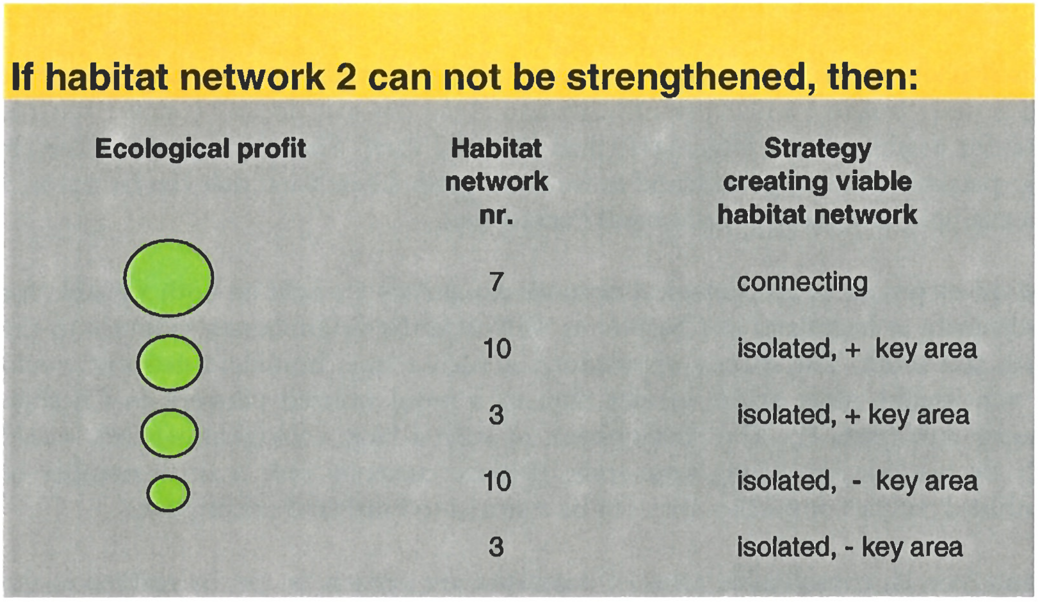


Figure 13 Spatial options for a viable habitat network for peatland sites in network 3

Table 38 Priority order of restoration of peatland sites according to strategy 2. The size of the green circles indicates the degree of ecological profit. Habitat networks that are not mentioned have no potential for creating a viable habitat network for the ecoprofile 'Green hairstreak'

broad = *restoring sites with semi-natural vegetation that contrbute to the connection with neithbouring networks or to a sustainable isolated network*

minimal option = *restoring just enough sites for a sustainable network or connection with neighbouring sites (preferably sites with semi-natural vegetation are added)*



6.2 Heathland

For Heathland, the target ecoprofiles 'Common lizard' and 'Grayling' were selected. The spatial requirement of this ecoprofile is presented in Table 39.

Table 39 Characteristics of target ecoprofiles used for generating spatial options for an ecological network for heathland

	Common lizard	Grayling
Key area	25 ha	50 ha
Dispersal distance	1 km	5 km
Sensitive to barriers	yes	no
Area stepping stone	3 ha	
Area viable network (including key area)	75 ha	125 ha
Area viable network (without key area)	125 ha	125 ha

6.2.1 Generating spatial options for lowland heath

Two axes of potential areas for heathland development that also contain actual patches of lowland heath can be distinguished. Both axes have a north – south direction. Axis I (Figure 14) is situated in the east of the County and connects suitable but little or small areas of existing heathland situated to the north and south of Cheshire in neighbouring counties.

Axis II is situated in the west of the County along the mid-Cheshire sandstone ridge and is more isolated; a network of heathland along this axis doesn't connect suitable areas for heathland on a larger scale than Cheshire itself. This axis contains relatively large patches of existing heathland as well as degraded heathland that can be restored (for example, at Delamere Forest and Peckforton).

The development of an ecological network along Axis I would be both valuable for biodiversity in heathland in Cheshire as well as in the neighbouring counties to the north and south. The species populations in such a large heathland network would be very stable: more stable in fact than in a more isolated network in Cheshire County only (Axis II). The development of such a large ecological network would only be possible on a long time scale, because currently only a small number of heathland patches or patches that can be restored to heathland are present.

Along Axis II, considerable areas of heathland are present or can be realised in the short term. Furthermore in the area along Axis II, the transport infrastructure fragmenting the network is less dense than in the area along Axis I. Therefore, the option of creating an ecological network along Axis II is preferable.

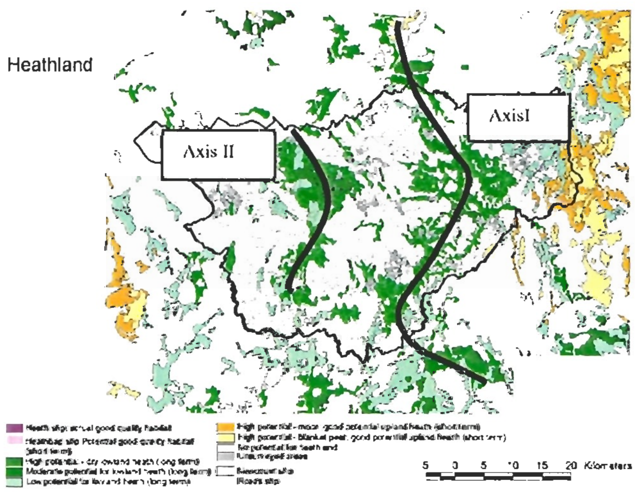


Figure 14 Two axes of areas with existing and potential for heathland can be distinguished

Target ecoprofile 'Common lizard'

Four areas with clusters of actual and potential habitat that can be restored in the short term are present (Figure 15). In clusters number 1 and 2 key areas can be created in the short term by restoring degenerated heathland sites (Table 40). In cluster 1 a road cuts across the key area, so mitigating measures (e.g. an ecotunnel) are needed to make the road permeable for non-flying species.

Putting effort into the creation of viable networks by restoring habitat and taking mitigating measures in respectively clusters 2 and 1 is most effective. When viable habitat networks in clusters 1 and 2 are realized, it is effective to connect clusters 1 and 2 by area 3. This connection can only be realized in the long term, and many mitigating measures are required for species that are sensitive to barriers. Connecting cluster 1 with cluster 2 is ecologically very profitable; it would have a stabilising effect on populations of many species. Putting effort in realising extra heathland in this area, however, is only profitable if viable networks can first be realized in clusters 1 and 2.

Creating extra hectares of heathland in clusters 4 and 5 may also result in viable networks. These networks, however, are isolated for species of the ecoprofile 'Common lizard'. Moreover, these networks can only be realised in the long term and require a relatively large amount of extra habitat. Restoring or promoting heathland in these areas is, therefore, a low priority ecologically.

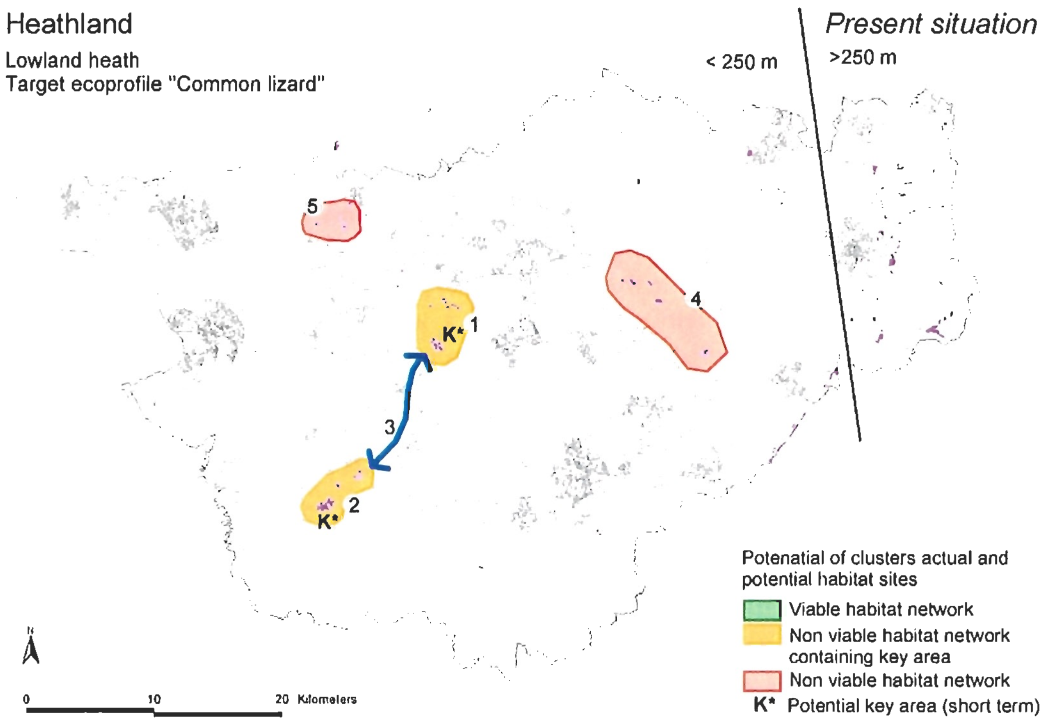


Figure 15 Clustering of (potential) habitat sites into (potential) networks, based on the ecological traits of the ecoprofile 'Common lizard'

Table 40 Priority order of restoration of heathland, based on the ecoprofile 'Common lizard'. The size of the green shapes indicates the ecological profit of the different spatial options

Lowland heath, target ecoprofile "Common lizard":

Ecological profit	Habitat network nr.	Strategy creating viable habitat network	
	2	enhance coherence within habitat cluster	+ key area - key area
if, then	1	enhance coherence within habitat cluster	+ key area - key area
	3	enhance coherence between cluster 1 and 2	+ key area - key area
	4	enhance coherence within habitat cluster	+ key area - key area
	5	enhance coherence within habitat cluster	+ key area - key area

Target ecoprofile 'Grayling'

Three large clusters of habitat can be distinguished in Cheshire (Figure 16). For species with this ecoprofile, key areas can be realised in clusters 1 and 2 in the short term. These areas coincide with the potential key areas for species of the ecoprofile 'Common lizard'. Creating enough habitat for a viable network for species such as the grayling, however, is only possible in the long term in both cluster 1 and 2. This because of its larger habitat requirements than the Common lizard ecoprofile. Restoring degraded heathland results in too little habitat for viable populations for species as the Grayling. Extra heathland creation, which can only be restored in the long term, is required to create room for viable populations of species as Grayling.

Connecting habitat networks 1 and 2 by creating stepping stones, or even a key area in between, would greatly enhance the stability of the network populations. Creating extra habitat in area 3 is only profitable if the habitat networks in clusters 1 and 2 are viable.

Creating a viable network in area 4 is also possible. Restoring an isolated habitat network in this area, however, takes a lot of extra hectares and has lower ecologically priority (Table 41).

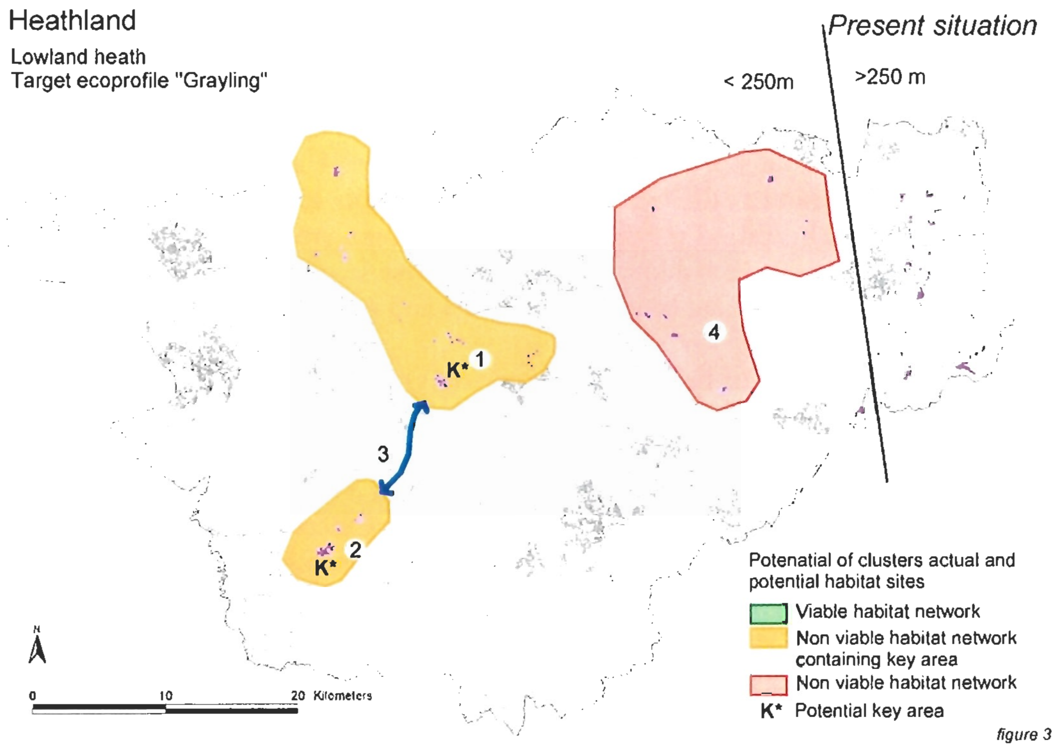
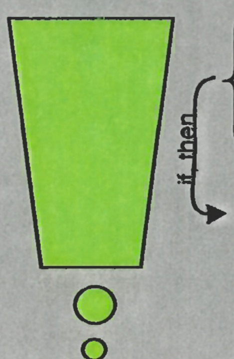


Figure 16 Clustering of (potential) habitat sites into (potential) networks, based on the ecological traits of the ecoprofile 'Grayling'.

Table 41 Priority order of restoration of heathland, based on the ecoprofile 'Grayling'. The size of the green shapes indicates the ecological profit of the different spatial options

Lowland heath, target ecoprofile "Grayling":



Ecological profit	Habitat network nr.	Strategy creating viable habitat network	
	2	enhance coherence within habitat cluster	+ key area - key area
	1	enhance coherence within habitat cluster	+ key area - key area
	3	enhance coherence between cluster 1 and 2	+ key area - key area
	4	enhance coherence within habitat cluster	+ key area - key area

6.2.2 Ecological ranking of spatial options

Combining the ecological profit of the various spatial options for species with the ecoprofiles 'Common lizard' and 'Grayling' results in the ranking of potential restoration areas (Table 42). Restoring habitat in clusters 1 and 2 is most profitable. If a considerable amount of habitat is restored, preferably to key areas, the next best option is to create heathland patches in area 3 (stepping-stones between the habitat network 1 and 2 result in stable populations). If this is not possible, the next best option is to restore and create heathland in area 5 and 4.

Most ecological profit can be gained by creating viable habitat networks in areas 1 and 2, with key areas of 50 ha for 'Grayling' (50 ha), and by increasing the density of the habitat network as much as possible. The next option is to connect these two habitat networks with stepping stones (3 ha, maximal 3 km apart) in area 3 and to implement mitigating measures to make the transport infrastructure permeable for non-flying species. If this can be done, then viable populations can be created for species of both ecoprofiles.

Table 42 Priority order of restoration of heathland, based on ecoprofiles 'Common lizard' and 'Grayling'. Viable networks that can be developed in the short term are given a higher priority than those that can only be developed in the longer term

Profit ecological profiles of Lowland heath, investing in:

habitat cluster	profit ecoprofile "Common lizard"	profit ecoprofile "Grayling"	"total" ecological profit	priority for investing
2	xxx	xx	xxxxx	
1	xxx	xx	xxxxx	
if, then 3	xx	xx	xxxx	
5	x	xx	xxx	
4	x	x	xx	

6.3 Rivers

For rivers, the target ecoprofiles 'Sedge warbler' and 'Water vole' were selected. The spatial requirements of these ecoprofiles are presented in Table 43

Table 43 Characteristics of target ecoprofiles used for generating spatial options for an ecological network for rivers and floodplains

	Sedge warbler	Water vole
Key area	100 ha	Length of habitat along watercourse: 40 km
Sensitivity to barriers	No	Yes
Dispersal distance	10 km	3.2 km
Home range	200 m	250 m
Area sustainable network (including key area)	400 ha	80 km
Area sustainable network (without key area)	600 ha	100 km

6.3.1 Generating spatial options for rivers

Target ecoprofile 'Sedge warbler'

Wetland species like the Sedge warbler find a very large habitat area in the tidal floodplains in the Northwest of Cheshire, which is large enough to sustain viable populations (area 1 in Figure 17; see also Figure 18). This area can be considered as the 'stronghold' for populations of these species (NB. this appeared later to be incorrect; area 1 does not contain reed beds and is therefore not a stronghold for species as Sedge warbler).
Another strong area is also in the tidal floodplains, but more inland (area 2 in Figure 17). This area can accommodate key populations of species like the Sedge warbler. The coherence between area 1 and 2 (and with other habitat patches) is small, because only a small number of habitat patches are present inbetween the two areas (van der Sluis *et al.*, 2003).

All other habitat patches that are present are (very) small and occur scattered all over the county. Because of this they are part of one and the same habitat network. The coherence between the patches is low, however, because of their small size (van der Sluis *et al.*, 2003). The small habitat patches show some clustering (area 3 to 9 in Figure 17).

The coherence of area 1 and 2 with surrounding areas is small as a result of little habitat area in areas 3, 7 and 9. The populations of species like Sedge warbler in area 1 and 2 are, therefore, in danger of extinction in the long term.

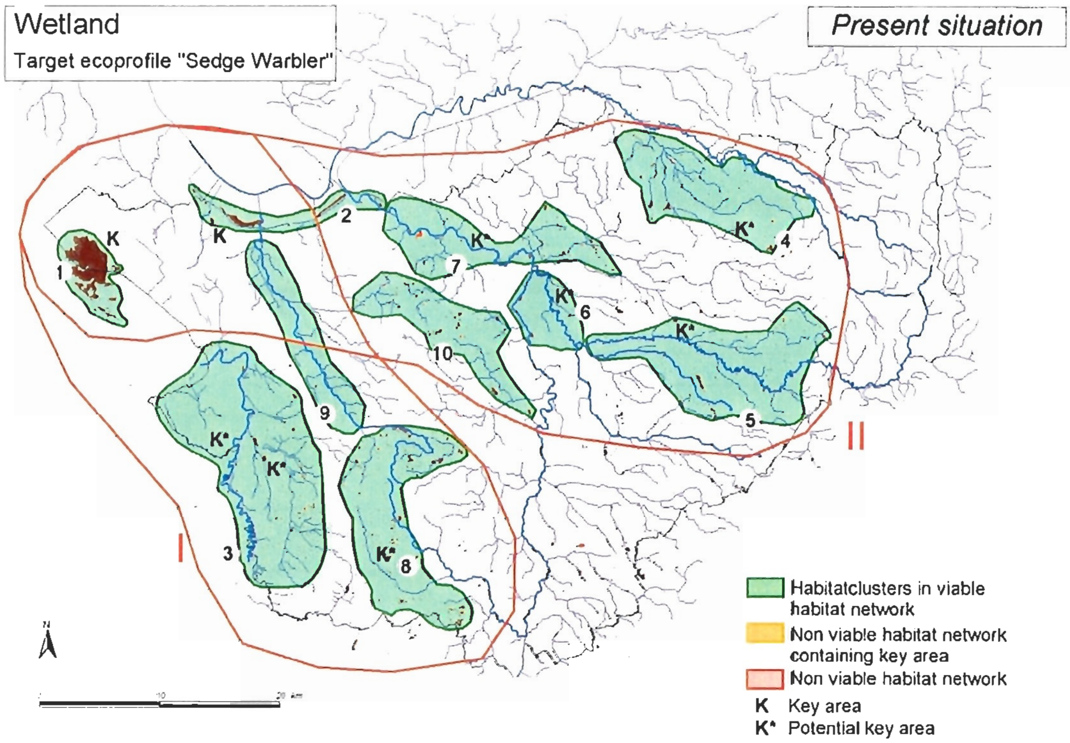


Figure 17 Clustering of (potential) habitat sites into (potential) networks, based on the ecological traits of th ecoprofile 'Sedge warbler'

Step 1: key population → viable population

To improve the habitat network for species such as the Sedge warbler, the best option from an ecological point of view is to enlarge the habitat area in area 2 (Figure 17) to such an extent, that the habitat network in this area can accommodate viable populations of such species. To achieve this, about 200 ha of extra wetland area should be restored. The surrounding area offers enough potential to realise this hectarage (Figure 4).

Step 2a: strengthen habitat clusters closest to the stronghold(s)

The next best option is to strengthen the habitat clusters that:

1. are close to the strongest parts of the habitat network; areas 1 and 2;
2. and contain the most suitable habitat.

This means that strengthening clusters 3, 9 and 7 (after area 2 is enlarged) is the next best option. This to such an extent that they can accommodate viable populations of species like the Sedge warbler, preferably including a key area. When a key area can be realised in a habitat cluster, a total of 400 ha of wetland area is required for viable populations of these species. When no key area can be realised, a total of 600 ha of wetland habitat is required for viable populations.

If the required area for a viable population cannot be restored, another option is to try to extend the wetland habitat in such a way that the area can accommodate key populations of these species (>100 ha). In that case, step 2b is of importance to obtain a sound ecological network.

Step 2b Strengthen coherence between stronghold and adjoining key areas.
An isolated key area is not enough to sustain a viable population. However, when a key population can communicate by dispersal movements with a large habitat patch such as as area 1, it becomes part of a very sustainable network.

The coherence between adjoining habitat areas 1 and 3 e.g. can be improved by realising a number of stepping stones, or even better: key areas, in between the habitat areas.

Step 3: strengthen habitat clusters that are best connected to stronghold(s)
Choose the best options, depending on the possibilities for the rehabilitation of riverbanks and floodplains that policies or other land use functions or offer. In this particular case: weigh the ecological gain with the development of wetlands in axis I or axis II (Figure 17).

Wetland development in one axis will be more profitable than investing the same area scattered over two axes. The development of a wetland network along axis I seems to have best chances, as area 3 is closest to the stronghold in area 1.

Target ecoprofile 'Water vole'
Species like the Water vole have potential for a viable population in three areas in the county (Figure 19, areas 1, 2 and 3). Area 1 can by far house the largest population, and can also be considered as the stronghold for these species. Two key areas are also present (area 4 and 5; Figure 19). These habitat networks with key areas are too small to sustain viable populations. Further, many small habitat patches are present, scattered over the county (areas 6 – 10 in Figure 19).

The ecoprofile 'Water vole' is sensitive to road and railway barriers. However, these wetland species have a special characteristic: they can move through water and watercourses. By following these water courses they are less likely to be troubled by infrastructure barriers. Connection of habitat patches by water courses mitigates the effect of habitat fragmentation by roads or railways.

To sustain a key population of species like the Water vole, 40 km of banks with adjoining semi-natural vegetation is required (more or less uninterrupted with a gap maximum of a few hundred meters). For a viable habitat network, an extra 40 km suitable banks are required(with a maximum gap of 3 km between suitable banks). Without a key area, 100 km of natural banks can sustain a viable population.

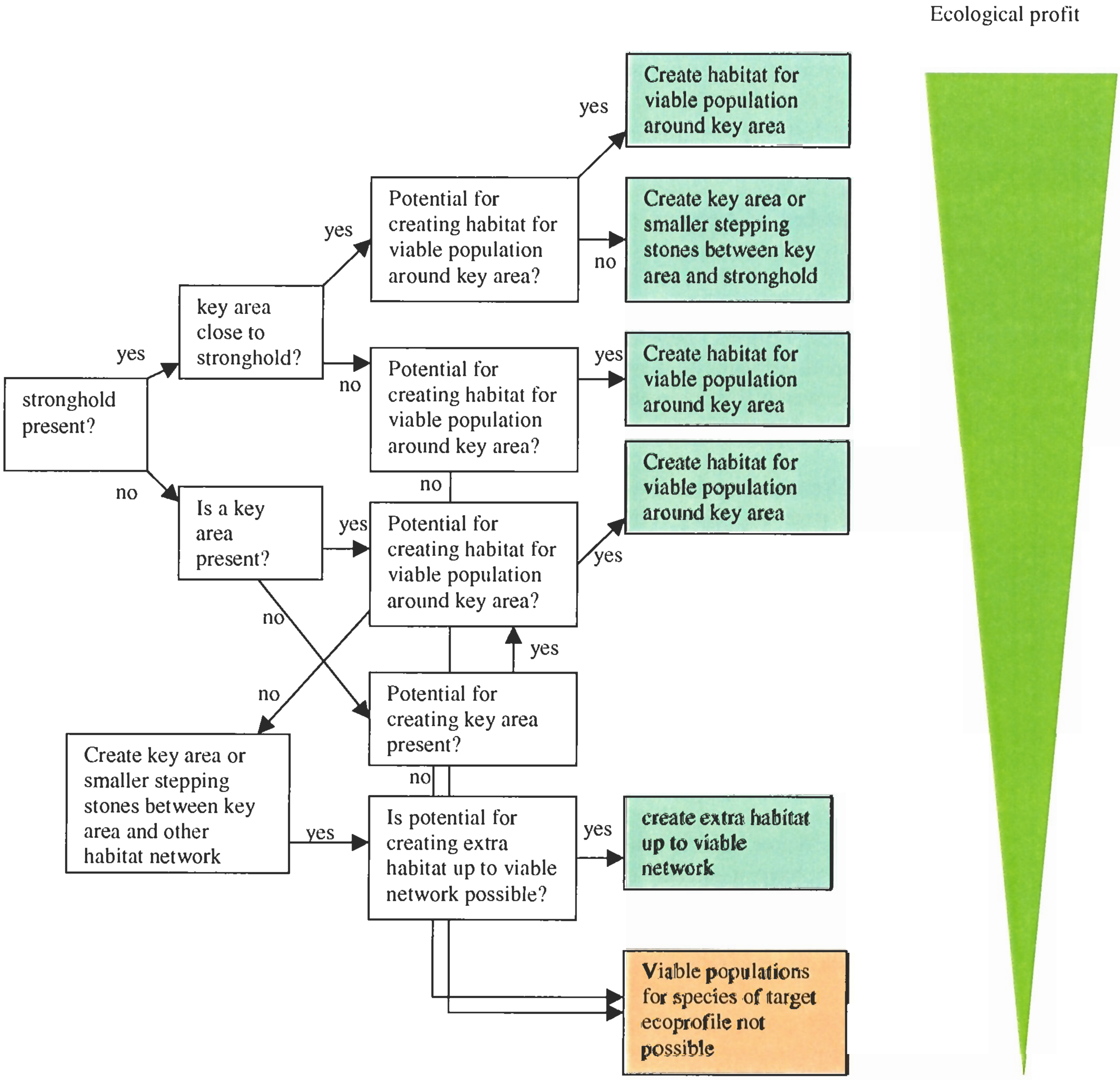


Figure 18 Decision tree for prioritising spatial options for rivers

The priority order for the rehabilitation of natural riverbanks and floodplains from an ecological point of view for species like the Water vole is determined as follows(Figure 18):

1. Wetland development in area 4, as:
   - Area is connected with the stronghold in area 1 by a watercourse
   - Area is close to stronghold in area 1
   - A key area is present
   - potential for enough wetland development for a viable habitat network.

2. Wetland development in areas 7 or area 9, as:
   - Area is connected to habitat network in area 3 by a watercourse
   - Area is close to viable habitat network in area 3
   - Area covers a part of the river basin and habitat patches are connected by watercourses
   - Area has potential for the development of a key area and viable habitat network.

3. Wetland development in area 5:
   - Contains a key area
   - Area has potential for the development for viable habitat network
   - Therefor option 3 is chosen

In addition, the habitat clusters in areas 8, 9 and 10 (or the area south of area 6) offer potential for the development of a key area or a viable network. The starting point in these areas from an ecological point of view is, however, worse than in the areas mentioned above (little habitat present, little potential for wetland development, far away from viable habitat networks). However, when development of wetland is favourable from another point of view, the potential for viable habitat networks are present and wetland development can be considered as well.

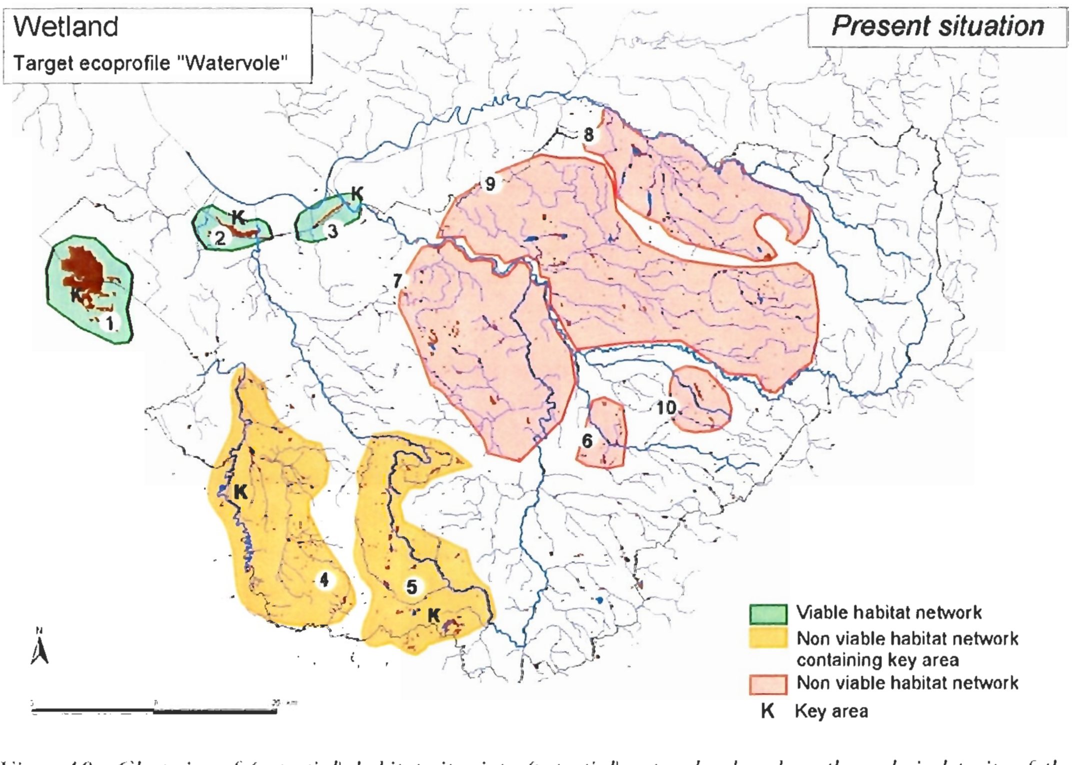


Figure 19 Clustering of (potential) habitat sites into (potential) networks, based on the ecological traits of the ecoprofile 'Water vole'

6.3.2 Ecological ranking of spatial options

The ranking of spatial options for viable habitat networks for species of the ecoprofiles 'Sedge warbler' and ' Water vole' largely coincide. The overall ranking is as follows:

- Try to accommodate species of both ecoprofiles close to strongholds in the west of Cheshire County
- Try to develop adjoining wetland areas. Two axes of adjoining areas can be distinguished: one in the west and one in the south. The development of the south axis has far more priority than that of the west axis
- Try to develop wetland in parts of the river basin, so that populations of wetland species are in contact with each other through watercourses. This also mitigates the effect of fragmentation by roads.

6.4 Woodland

For woodland, the target ecoprofiles 'Dormouse' and 'Marshtit' were selected. The spatial requirement of this ecoprofile is presented in Table 44.

Table 44 Characteristics of target ecoprofiles used for generating spatial options for an ecological network for woodland

	Dormouse	Marshtit
Key area	100 ha	300 ha
Dispersal distance	1.5 km	11 km
Sensitive to barriers	yes	no
Area stepping stone	-	30
Area viable network (including key area)	150 ha	450 ha
Area viable network (without key area)	200 ha	600 ha

6.4.1 Generating spatial options for woodland

Target ecoprofile 'Dormouse'

There are three areas in the County that contain patches of woodland habitat, not divided by infrastructure, covering enough area to accommodate viable populations of species like the Dormouse. The most viable habitat network is situated north of Delamere Forest in the Lower Weaver Valley and includes a key area (Figure 20, nr 1). The other areas are situated in the south west of Cheshire (Peckforton – Bickerton) and south of the Pennines around Shell Brook (Figure 20, nr 4 and 6). These areas are just large enough for viable populations for species like the Dormouse. All three habitat networks contain a key area.

Some parts of Cheshire contain a very dense pattern of woodland habitat patches, especially areas 7 and 8 in the east of the county. A similar patch is found in the south of Cheshire (area 5). Infrastructure, however, divides the habitat pattern into a large number of small habitat networks for non-flying species. Mitigating measures might fuse the more isolated habitat networks into one larger habitat network, offering a higher potential for biodiversity. By making only a few roads permeable for non-flying species in area 7, for example, the habitat network can even contain a key area.

Large parts of the County have been planted with coniferous forest, and do not offer good habitat quality for specific woodland species. Converting these forests into broad-leaved woodlands can offer extra, good quality woodland habitat in the present habitat networks. Converting the conifers to broad-leaves in Delamere Forest (area 3) creates even the possibility for a key area for species like the Dormouse (Figure 20).

For an ecological network for woodland, numerous spatial options are possible in Cheshire, especially for the high ambition level of 2,500 ha extra woodland. New, large areas of woodland, which might form the core of the network can be created anywhere, on any type of land. In ranking the infinite number of possible spatial options, therefore, the amount of effort to achieve ecological profit was also considered. We elaborated as much as possible on the present pattern of (ancient) woodland and infrastructure, and tried to gain the highest ecological profit possible, taking as few measures as possible. Connecting new woodlands with the present ancient woodlands will also benefit biodiversity in the new woodland areas. The existing ancient woodland will function as a source of ancient woodland species to colonise the neighbouring new planting.

The starting point for the design of an ecological network for the ecoprofile 'Dormouse' were the strongest habitat networks in the present situation (that is, areas 1, 6 and 4 in Figure 20).

Area 1 is situated close to Delamere Forest (area 3). These both areas are very strong and its sustainability can be improved a lot by connecting it together. Converting the present coniferous forest in Delamere into a broad-leaved forest in the long term, would result in a very large, suitable habitat area for species like the Dormouse. By taking mitigating measures for the few roads in this area, good conditions for very viable populations would arise. By taking mitigating measures for infrastructure in area 2, the viable habitat networks 1 and 2 will be fused into one very viable habitat network important for the diversity of broad-leaved woodland species in Delamere Forest. Area 1 will function as a rich source of ancient woodland species for Area 3 Typical ancient woodland biodiversity in Area 3 will be achieved earlier if the area is connected to Area 1. Investing in mitigating measures in Area 2 only makes sense if Delamere Forest can be transformed into a broad-leaved forest. In that case, the added value of mitigating measures in Area 2 will be very high (Table 45).

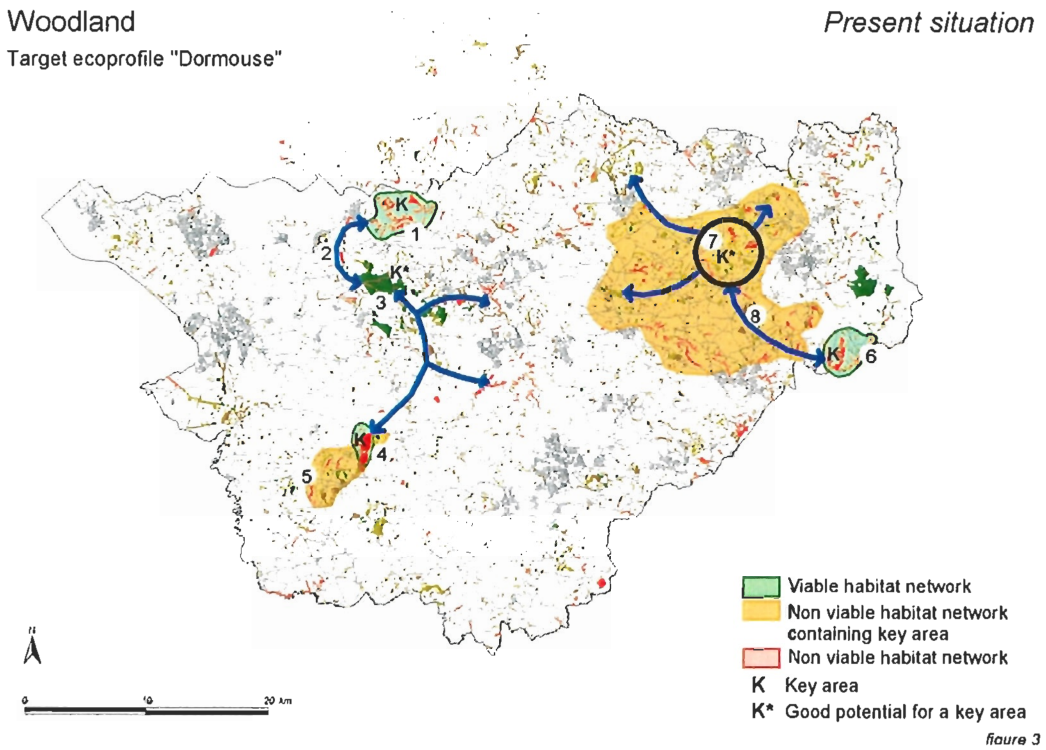


Figure 20 Clustering of (potential) habitat sites into (potential) networks, based on the ecological traits of the ecoprofile 'Dormouse'

Implementing mitigating measures in Area 4 will also have a large added value. A single road divides two large habitat networks in this area. Making this road permeable for non- flying species like the Dormouse, results in a substantial larger habitat network and in a much greater viability for similar species. Implementing mitigating measures on the boundary of Areas 4 and 5 and within Area 5 itself would result in an increased habitat network for non-flying species. The profit/effort ratio, however, is less attractive than taking mitigating measures within Area 4 alone. Improving habitat quality by converting coniferous forest into broad-leaved forest and by expanding woodland in the areas mentioned would further increase the ecological profit of taking mitigating measures.

If all these suggestions are put into practice, two large habitat networks are created (Areas 1+2+3 and Areas 4+5). It would be ecologically profitable to connect these two large habitat networks. The resulting north-south axis across the County could be extended further south to woodland sites in Shropshire and Wrexham, resulting in a very large, robust woodland network within Cheshire and beyond. With the expected changes in the climate, such a larger habitat network could accommodate a smooth shift of the biotopes of many species to another degree of latitude.

Investing in Areas 6 and 7 will also result in an ecological profit for relatively little effort. This profit will take considerably greater investments, however, than in west Cheshire. Enlarging and connecting woodland patches in Area 6 can consolidate its value for species like the Dormouse. At present, this area is only just large enough for viable populations. In Area 7, a dense pattern of woodland patches, cut by relatively little infrastructure is present. Mitigating measures will fuse the habitat networks in Area 7 into one large, probably more or less, viable network. Increasing the area of woodland will further increase the potential for viable networks. If viable habitat networks can be created in Areas 6 and 7, taking mitigating measures in Area 8 will improve the viability of these networks. However, a large distance has to be covered and many infrastructural barriers would have to be mitigated for non-flying species.

Table 45 Priority order of restoration of woodland, based on the ecoprofile 'Dormouse'. The surfaces of the green shapes give an impression of the ecological profit of the restoration of woodland in the distinguished networks

Woodland, target ecoprofile "Dormouse":

Ecological profit	Area nr.	Strategy creating viable habitat network
	3	improving habitat quality
	2	connecting habitat networks by mitigating measures
	4	enlarging habitat network by mitigating measures
	5	enlarging habitat network of area 4 by: mitigating measures improving habitat
	6	strengthen habitat network by enlarging patches
	7	enlarging habitat network by mitigating measures
	8	connecting habitat networks by mitigating measures

Target ecoprofile 'Marsh tit'
For flying species with dispersal traits such as the Marsh tit, all patches of woodland are part of one large, viable habitat network. So, the addition of extra woodland will not impact on the critical threshold for the viability of such species. Improving the network can, however, improve the viability of populations but is of secondary importance.

The present habitat network in Cheshire does not contain a key area for the target ecoprofile 'Marsh tit'. The viability of species is best served by creating one or more key areas.

In Cheshire, three areas are suitable for creating key areas (Figure 21) because the woodland patches are relatively large and the distance between woodland patches is relatively small. Considering size and configuration of the habitat patches, conditions for creating a key area are best in Areas 1 and 4 (Table 46).

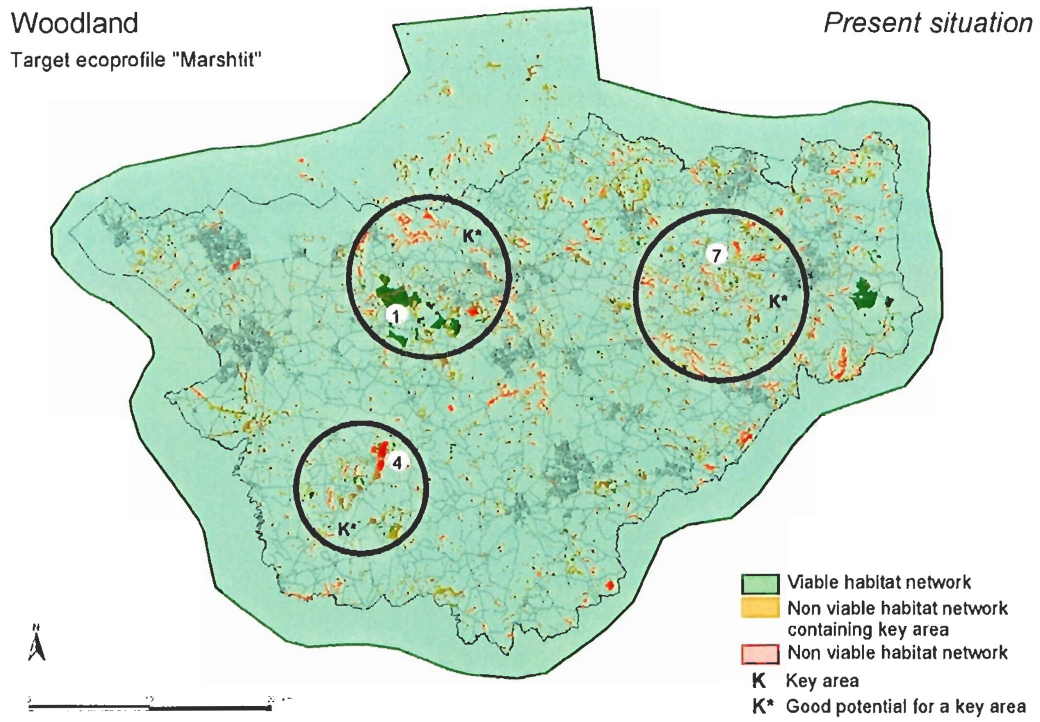


Figure 21 Clustering of (potential) habitat sites into (potential) networks, based on the ecological traits of the ecoprofile 'Marsh tit'

Table 46 Priority order of restoration of woodland, based on the ecoprofile 'Marshtit'. The surfaces of the green shapes give an impression of the ecological profit of the restoration of woodland in the distinguished networks

Woodland, target ecoprofile "Marshtit":

Ecological profit	area nr.	Strategy creating viable habitat network
	1	enlarging habitat areas, creating new habitat areas
	4	enlarging habitat areas, creating new habitat areas
	7	enlarging habitat areas, creating new habitat areas

6.4.2 Ecological ranking of spatial options

In Table 47 the ecological profit of both ecoprofiles are ranked. This is complicated, however, because many areas only generate ecological profit if conditions in other areas are also met.

The overall impression is that the ecoprofile 'Dormouse' should be leading for the design of an ecological network for woodland. The ecoprofile 'Marsh tit' stresses the importance of certain areas.

Table 47 Priority order of restoration of woodland, based on ecoprofiles 'Dormouse' and 'Marshtit'

Woodland, integrating ecoprofiles

area nr.	profit ecoprofile "Dormouse"	profit ecoprofile "Marshtit"	Total profit
3	+++	+	++++
4	+++	+	++++
7	+	+	++
2	(+++)	+	(+++)+
5	(++)	+	(++)+
6	+		+
1		+	+
8	(++)		(++)

(+) = + if conditions are met

6.5 Grassland

For grassland, the target ecoprofiles 'Common blue' and 'Barn owl' were selected. The spatial requirement of these ecoprofiles are presented in Table 48.

Table 48 Characteristics of target ecoprofiles used for generating spatial options for an ecological network for grassland

	Common blue	Barn Owl
Key area	20 ha	20 adjoining territories, of 50 ha of rough grassland each within an area of 300 - 1,000 ha
Sensitivity to barriers	yes	no
Dispersal distance	0.300 km	50 km
Home range	0.250 km	5 km
Area sustainable network (including key area)	50 ha	80 territories, of which 20 adjoining territories
Area sustainable network (without key area)	50 ha	120 territories

6.5.1 Generating spatial options for grassland

Target ecoprofile 'Common blue'
Two natural grassland areas are large enough to sustain viable populations for species like the Common blue[3]. In addition, 9 key areas are present, scattered over the County (Figure 22). Some key areas are situated quite close to each other, but are separated by roads (e.g. Area 1 in Figure 22).

Step 1: Improving local networks
To improve the conditions for populations of species like the Common blue, the best starting point are the key areas. Each of these grassland areas covers at least 20 ha. When these areas can be enlarged to 50 ha, the potential for viable populations will increase significantly (Figure 22, indicated with 'K'). Grassland areas should be contiguous, but when this is not possible, gaps of a few hundred metres between different grasslands within the same key area are acceptable

In theory, the low ambition level allows enlarging all key areas into viable populations. From the viewpoint of ecological coherence all areas are more or less equal. Opportunities for enlarging key areas will therefore be determined by other interests, such as, agricultural developments. Creating new local networks by promoting rough grassland is also an attractive option, if other land use functions allow this. This option is less attractive, however, than extending the area for species-rich grasslands.

Step 2: Increasing the density of clusters of networks
As the ecoprofile 'Common blue' is sensitive to roads, connecting different habitat areas is difficult. Although many species represented by this ecoprofile have problems crossing small roads, some individuals will be able to cross them safely. Large four-lane roads can be considered as impregnable barriers for all non-flying species. Connecting networks, even though they are separated by (small) roads, has a

[3] The LARCH analyses of the habitat of the Common blue and the Barn owl show slightly different results. This difference in valuation of the viability of the habitat network is due to the fact that different data on grassland have been used (paragraph 1.1).

positive effect on the long term survival of a number of species represented by the ecoprofile "Common blue".

It is preferable to enlarge key areas that are situated in or close to areas of (future) extensification of grassland management. Upgrading local networks into viable networks will achieve some coherence between those local networks currently divided by small, local roads, and will have a positive effect on biodiversity.

Figure 22 distinguishes 9 (clusters of) local networks. Increasing the density within and between adjoining networks can also increase grassland biodiversity. From an ecological point of view, there is no preference in the enlargement of specific networks. It is preferable, however, to improve *adjoining* networks, not separated by four-lane roads or large railways. So, the choice of which networks to enlarge, increase the density and/or connect will depend largely on the interests of the stakeholders.

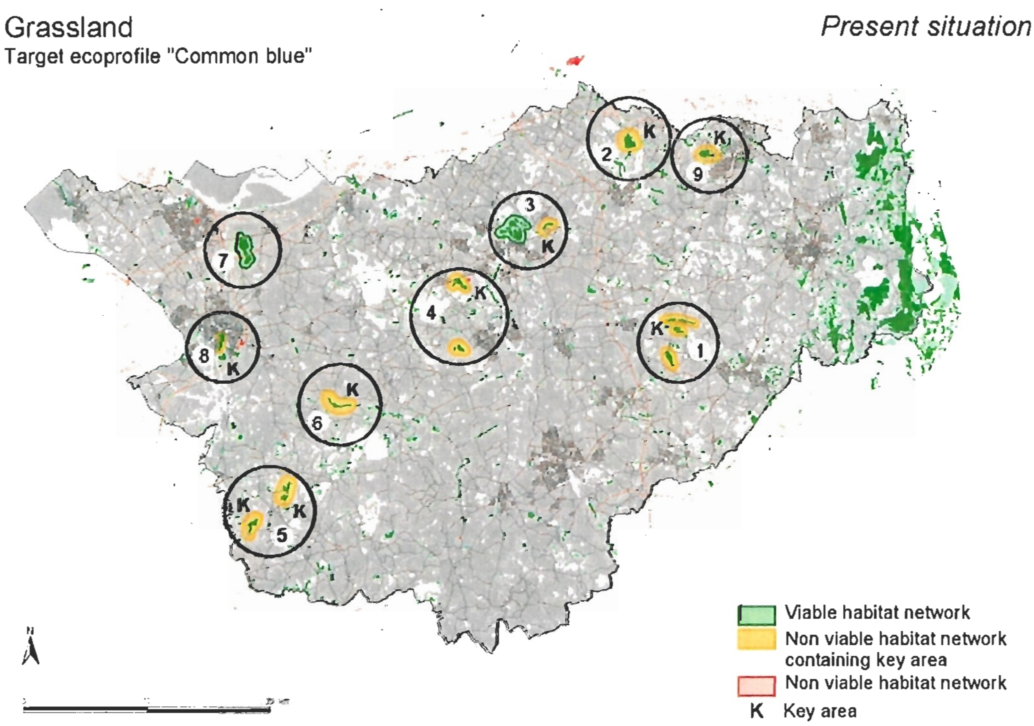


Figure 22 Clustering of (potential) habitat sites into (potential) networks, based on the ecological traits of the ecoprofile 'Common blue'

Target ecoprofile 'Barn owl'

The foraging habitat patches that are scattered over the county are part of one large habitat network for flying species with a dispersal distance like the Barn owl. The area of grassland in Cheshire alone is too small to house a viable population or even a key population of these species.

A viable network including a key area for species like the Barn owl will take at least 80 x 300 ha = 24,000 ha. This kind of area cannot be found in the County itself (total of Cheshire County area (including the Pennines, which is unsuitable habitat for the Barn owl), is 210,000 ha). So, only if suitable foraging area and nesting places are available in the adjoining Counties, will species like the Barn owl have the potential to form viable populations in Cheshire and its surroundings.

So the first consideration should be (Figure 23):

If grassland patches in Cheshire are not part of a larger county-exceeding network:
When areas with suitable habitat do not extend beyond the county boundaries, the conditions for a viable population cannot be met in Cheshire County.

If grassland patches in Cheshire are part of a larger county-exceeding viable network:
Then the viability of populations of species like the Barn owl can be (slightly) increased by creating extra areas of rough grassland that meet the conditions for a territory (at least 50 ha in an area of 300 ha).

However, when a key area, consisting of at least 20 adjoining territories, can be realised in Cheshire, this will contribute significantly to the viability of populations in the total habitat network. If the county-exceeding network option is not viable, the creation of a key area in Cheshire can have a crucial effect. Adding a key area to the network could possibly make the difference between a potential viable and a non-viable network. By adding some potential territories to the network, the conditions for a viable population only slightly improve.

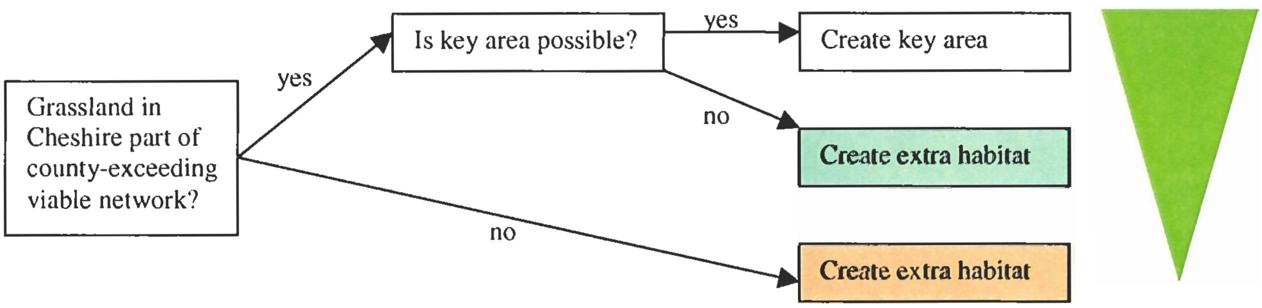


Figure 23 Decision tree for prioritising spatial options

6.5.2 Ecological ranking of spatial options

The discussed spatial options for grassland for both ecoprofiles are more or less the same. They can be integrated in the following way:

Try to create as much as possible adjoining grassland areas larger than 50 ha, for species as the Common blue. Such areas will also be suitable territory for species as the Barn owl.

If it is impossible to create unfragmented grassland areas, try to create at least 50 ha in an area of 300 to 1000 ha (enough for a territory). This will increase the habitat network of the Barn Owl. If a number of 20 adjoining territories can be realised, a large contribution can be made to the viability of these kind of species. If the rest of the (probably vast) habitat network offers conditions for creating ten or more territories, Cheshire county can house a stable population of species as the Barn owl, and contribute to a positive, stabilising effect on the total habitat network.

7 Step 4: Ranking of spatial options

In a joint workshop between the Life ECOnet team and Alterra project team, the results of the spatial options set out in Chapter 6 were discussed. The objectives for the workshop were:

- to ecologically verify the spatial options and to prioritise the potential nature development areas
- to map future developments in Cheshire County that can obstruct or enhance the development of nature areas (urban planning, planned infrastructure, mineral extraction)
- to use the stakeholder analyses carried out by the ECOnet team together with the future development map to prioritise the areas again based on both ecological profit and on other developments and functions in the County

In this chapter, the repercussion of this workshop is presented. Paragraph 7.1 deals with the ecological verification of the spatial options and the stakeholders' opinions and preferences. In paragraph 7.2 the future developments are presented. The result of the integration of this information into a draft ecological network for Cheshire is shown in 7.3. This provisional ecological network is presented and explained extensively in chapter 8. The presentation given by Paul Opdam as an introduction for this workshop is put down in Annex 2 of this report. It was also agreed to include available information on minimum requirements of corridors in Broekmeyer & Steingröver, 2001 (Annex 3).

7.1 Ecological verification of spatial options

7.1.1 Meres and mosses

The remarks in the workshop on the potential for the rehabilitation of meres and mosses of the areas that are shown in Figure 9 are listed below (Figure 24):

Area 1:	Blanket bog in the Pennines is different from lowland peatland. They are sufficiently different habitats not to justify linkages with Area 2. Better to consolidate peat within the individual clusters.
Area 2:	Good idea.
Area 3:	Degraded habitat. Would require more cost.
Area 4:	Has good potential and this is part of English Nature Midlands Region Meres and Mosses Strategy.
Area 5:	Good potential for heathland, peatland and woodland. Difficult to reconcile priorities for different habitat in Delamere Forest English Nature - the peat can be rewetted in some places, but in others may be better to go to heath vegetation.
Area 6:	Is managed by Cheshire Wildlife Trust as a nature reserve. Effectively wet grassland - rather than peatland site.

Areas 7, 8, 10: have low potential for the rehabilitation of meres and mosses (e.g. Whitley Reed is more of a wetland).

General remarks:

- Peat forms a complex with other habitats, and linkages with meres and woodlands may be desirable
- M6 motorway goes through Areas 9 and 3
- Extremely difficult to link the different networks because they are remote and scattered. So the only option is to look at the individual networks separately. The axes are unrealistic.
- For many species the network is peatland plus wetland types.

Concluded that Areas 5 and 2 have the best potential for the development of meres and mosses. Area 4 also has good potential, because of the relationship to the south over the county boundary with meres and mosses in Shropshire.

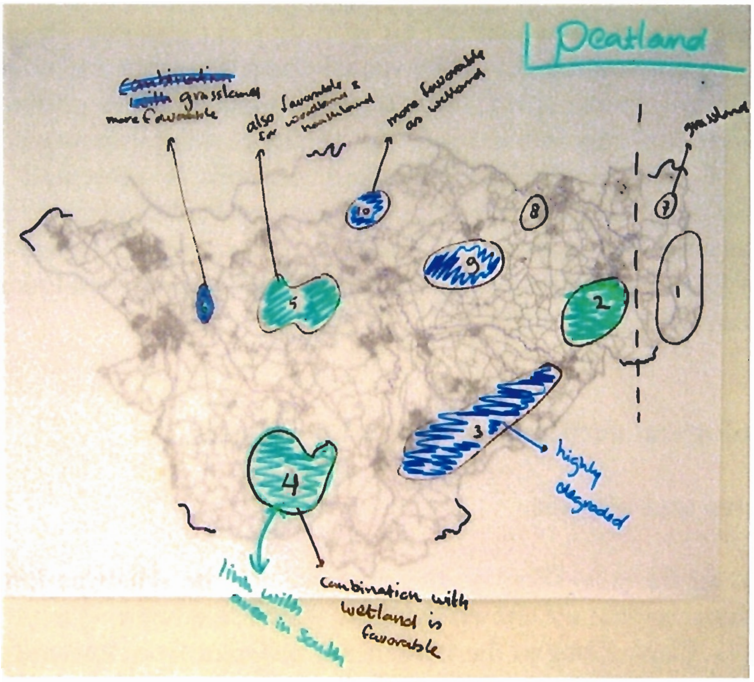


Figure 24 Result of workshop; remarks on the spatial options for meres and mosses

7.1.2 Heathland

The remarks in the workshop on the potential for the development of heathland in the areas that are shown in Figure 15 are listed below (see also Figure 25):

Areas 1 and 2: good potential. In both cases questions were raised over clash with other habitat development.

Area 1:	has quarries and potential for further heathland development. But many quarries are lakes. Future extraction may be above water level.
Area 3:	Nobody thought there was much point in linking Areas 1 and 2 by heathland development in Area 3. It was considered impossible to develop the link because of abiotic conditions and the distance between the two.
Area 5:	unrealistic. There is some heathland on Helsby Hill. National Trust wanted to buy land adjacent and failed but persuaded neighbour to enter Countryside Stewardship.
Area 4:	low potential.
Area 5:	does not have 75 ha of land available to develop a key area. No potential to create a key patch, so should be left out of the scenario.

The Cloud at Congleton is an important area, but is really upland heath. National Trust owns it, but there is little potential for expansion. There are linkages south over the border.

Concluded that the enlargement of lowland heathland in Areas 1 and 2 is ecologically the most profitable. Area 3 needs links to help as stepping stones (maybe patches of grassland). For the ecoprofile 'Common lizard', however, these stepping stones are not suitable. Finally, the enlargement of Areas 4 and 5 are profitable but need much more investment for creating new habitat areas.

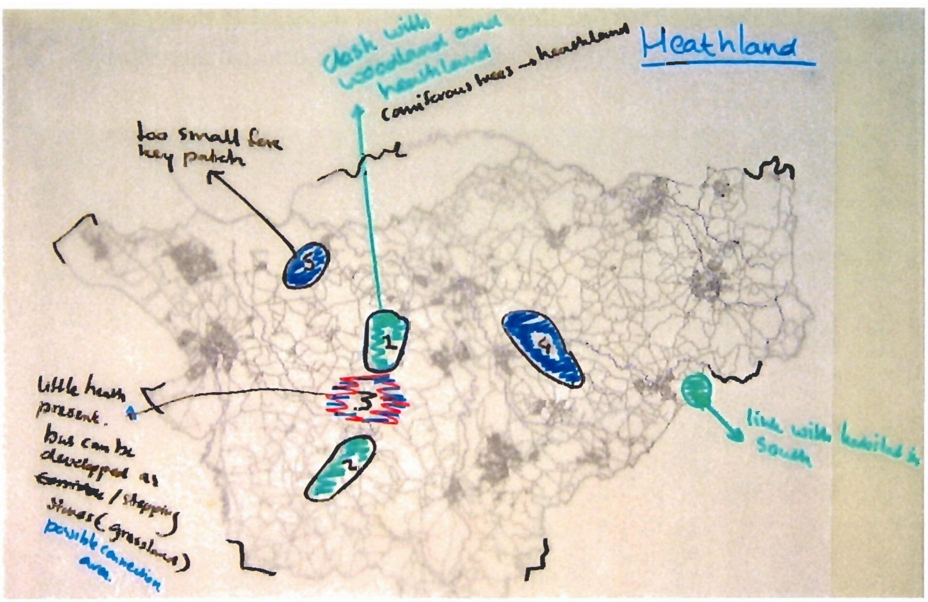


Figure 25 Result of workshop; remarks on the spatial options for heathland

7.1.3 Woodland

The remarks in the workshop on the potential for woodland of the areas that are shown in Figure 20 are listed below (see also Figure 26):
Area 1: important. Woodland planting going on already.
Area 3. expansion of broadleaves is desirable.
Area 2: favourably received, Woodland Trust buying land in this area already.
Area 4: ecologically sound and well received by stakeholders
Area 5: ecologically sound and expansion is possible.
Area 6: ecologically potential, expansion is possible.
Several areas seem to be missing and are added to the map during the workshop.

Further remarks:

- In south of county there are more hedgerows and hedgerow trees
- Wych Valley not identified, with good linkage south into Wales
- Weaver Valley under represented. Dane Valley under represented - and links between the two.
- Boundary arguments
- Chester City Council's green networks not represented and may conflict, but they were not identified scientifically

Concluded that a network of woodland in the west of the county (Areas 1 to 5 and further to the south) and in the east in the county (Areas 6 to 8 and further to the south) can be developed. The development of the woodland network in the west of the county is more desirable and profitable than in the east of the county.

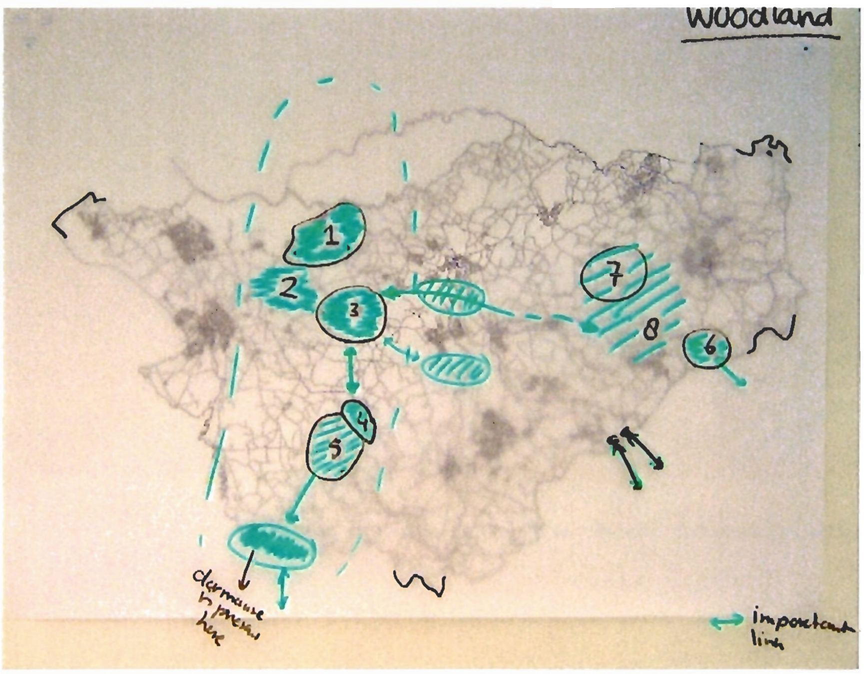


Figure 26 Result of workshop; remarks on the spatial options for woodland

7.1.4 Grassland

The remarks in the workshop on the potential for the development natural grassland in the areas that are shown in Figure 22 are listed below (see also Figure 27):

- Very fragmented situation,
- Connect areas 6 and 7 (wet grassland),
- Some potential areas are not on the map; these were added,
- Lots of constraints for the development of large areas of grassland,
- Spatial options less well received by stakeholders.

Concluded is that area 1, 7, 8, 6, 5 and the area between Areas 6 and 7 and an area near Willington are suitable for the development of large grassland areas.

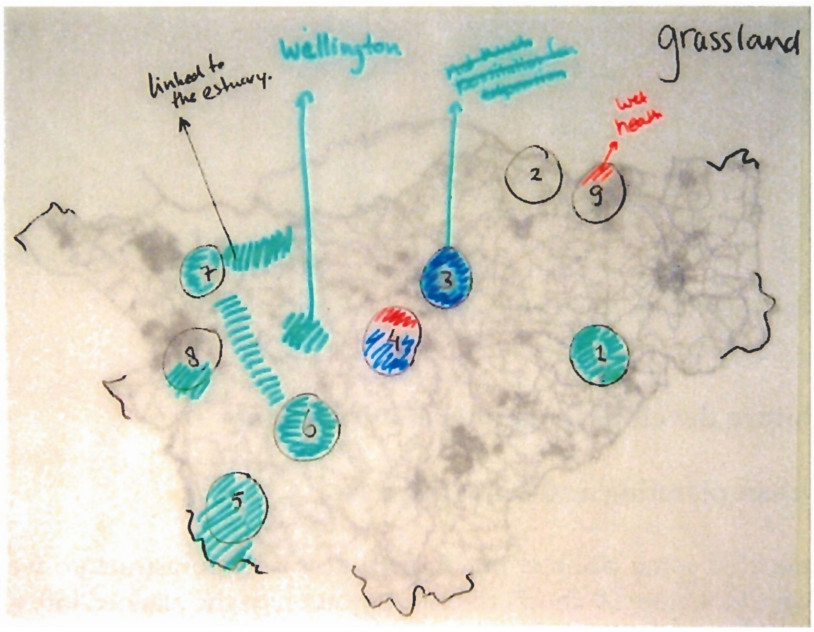


Figure 27 Result of workshop; remarks on the spatial options for grassland

7.1.5 Rivers

The remarks in the workshop on the potential for woodland of the areas that are shown in Figure 17 and Figure 19 are listed below (see also Figure 28):

- One habitat that didn't work for people. The most diverse group of habitats - meres, ponds, rivers. Agreed to restrict the habitat types to rivers.
- Area 1 in Figure 17 is not a key area for sedge warbler, or for water vole. Needs to be taken out of the analysis. Agreed to remove this.
- No decent inventory of reedbed and other floodplain habitats available.

Concluded that Area 2 has high potential for extensive wetland development and along the River Dee and River Gowy (Areas 1 and 3; Figure 17) have the best possibilities for rehabilitation of floodplains and banks. These river systems have an (inter)national protection status.

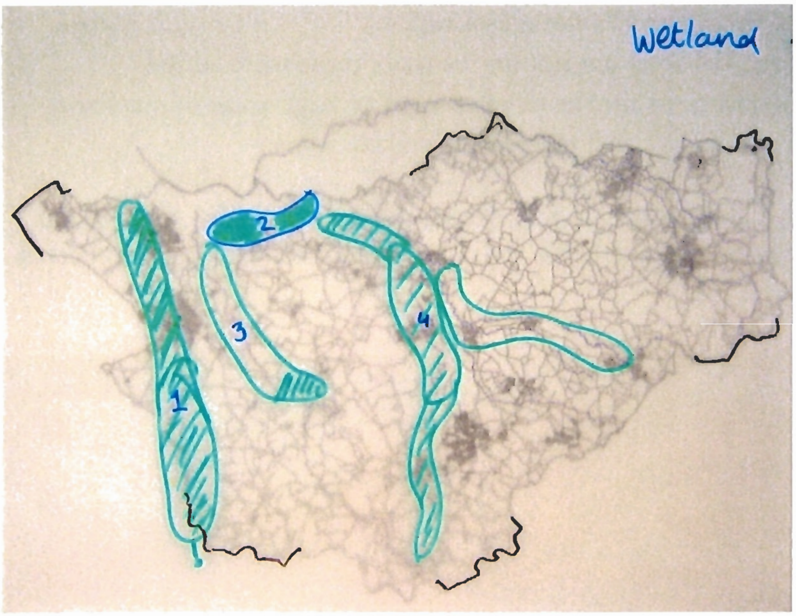


Figure 28 Result of workshop; remarks on the spatial options for rivers

7.2 Future developments in Cheshire County

7.2.1 Urban planning and infrastructure

The locations of some planned new urban areas and infrastructure were put on a map (Figure 29). Figure 30 shows the exact location of the planned infrastructure.

Figure 29 Result of workshop; expected spatial developments in Cheshire County in urban planning and infrastructure

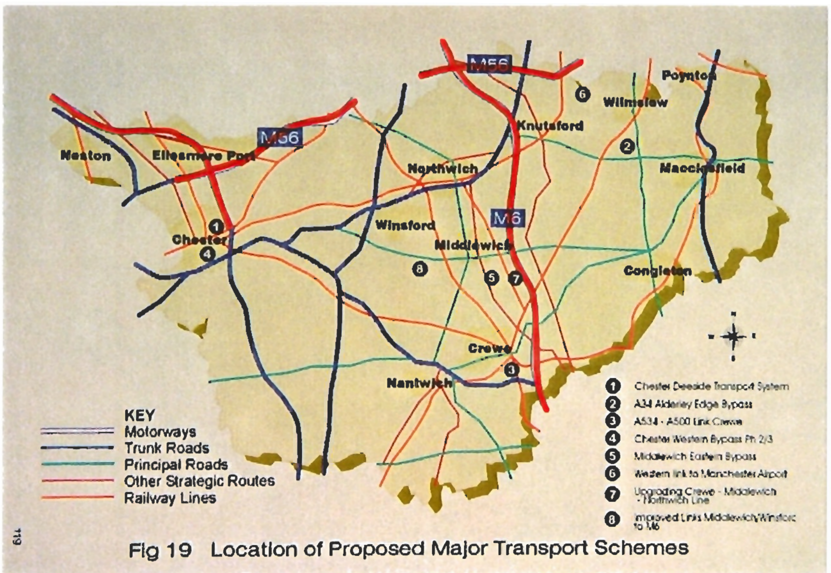


Figure 30 Location of proposed major transport schemes

7.2.2 Extraction of minerals and waste sites

Sites that are assigned for the extraction of minerals or deposition of waste can be seen as large opportunities for the subsequent development of semi-natural habitats. Those sites that will be used as extraction or waste sites were put on the map (see Figure 31).

7.3 Final integration of different ecosystems

For the final integration of the areas of the 5 different ecosystems, two different maps were envisaged: one showing the situation with all of the most suitable areas for the development of all 5 ecosystems, and a second map with all second choice areas for the 5 ecosystems.

The intention was to put areas of different ecosystems onto a final map in such a way that the areas of ecosystems that can reinforce the quality of one another (e.g. woodland and heath) coincided as much as possible, and also that areas of ecosystems that excluded each other do not clash. It was also intended to show the areas with good possibilities for and constraints to nature development as a result of future development. Depending on these possibilities, constraint and clashes, a final choice is made for the areas of all ecosystems that are proposed to comprise the provisional ecological network.

In this case, it appeared that the most suitable areas of the 5 ecosystems did not clash. Additionally some second choice areas were included in the map, in those instances where it was assumed that the ambition level was not yet met.

The mid-Cheshire sandstone ridge stands out as the backbone of a network of woodland, heathland and meres and mosses (Figure 31).

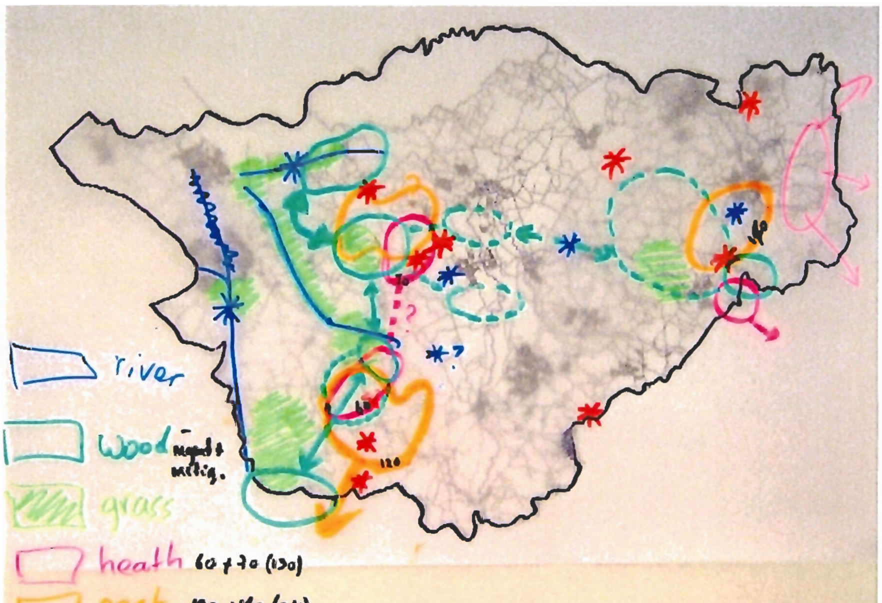


Figure 31 Result of workshop: Draft of provisional ecological network for Cheshire County
Red stars: good opportunities for ecosystem development as a result of mineral extraction or waste sites.
Blue stars: areas that put constraints to the development of an ecological network as a result of future developments in urban planning and infrastructure.

8 A vision of an ecological network for Cheshire County

This chapter proposes a vision of an ecological network for Cheshire County. We summarise the logic behind the working process, the steps towards prioritising local areas for landscape development and describe the network in the context of ecological conditions and opportunities in relation to trends in other land use types.

8.1 Developing an ecological network for improved quality of nature

An ecological network is a means, a remedy for improving nature; it is not the goal itself. The network we propose does not prescribe in detail to what extent and exactly where in Cheshire County nature should be improved. Instead, it indicates where the most profitable locations for improvement are situated. By profitable we mean conditions that are both ecologically effective and socially and economically favourable.

We start from the fact that Cheshire County is pursuing a (re)development of the landscape with the aim of improving the quality of nature. The motivation for that choice is not the subject of this exercise; it is the starting point.

Another starting point is that it will be uncertain when and for how long certain opportunities, societal support and funding will be available for improving the quality of Cheshire's nature. A vision of an ecological network cannot and should not, therefore, be the ultimate goal. Thus we present a pathway along which an ecological network with the best ecological conditions (best value for money) and the best opportunities for landscape development can be reached.

8.2 Defining the ambition level

Species in Cheshire County differ in the ecosystems they inhabit, in the spatial scale of their networks and in the way they move through the landscape. Species show a wide variation in area requirement and in the necessity of connecting landscape structures. We used a matrix in which species are arranged according to their dispersal distance and area requirements. In this way we are able to cluster species into groups called ecoprofiles.

Nature quality in Cheshire County is defined in terms of 'biodiversity levels' rather than in terms of flagship species. The basis for our approach is a set of ecoprofiles, of which each ecoprofile is coupled with ecological conditions for sustainable populations of species they represent, a 'biodiversity level'. We used a landscape cohesion assessment tool (LARCH) to diagnose the habitat networks in the actual situation for a number of ecoprofiles. We looked for those networks that were just below the threshold of sustainability, but that could be made sustainable by the aspired landscape development. Per ecosystem, a number of alternative options for nature development were described, all resulting in better conditions for sustainable populations.

The higher the target for biodiversity is set, the more money is required to realise it. Higher biodiversity targets mean more ecoprofiles for which persistent conditions have to be created in the landscape, the greater the area that is needed and thus the greater costs that are involved. Defining the targeted level of nature quality is linked, therefore, with the expected amount of funding.

In Cheshire County the amount of funding was and will stay uncertain for a long time. Funding conditions may improve during the process. Therefore we did not develop the one and only network for Cheshire County, but defined a number of spatial options for nature improvement and ranked them according to ecological and socio-economic criteria. Herewith we took into account the area indicated by Cheshire County Council that might be minimally and maximally available in the future.

Some principles on ecological networks

Why ecological network as a strategy?
It is common knowledge that nature quality depends on good abiotic conditions. Recent insight from spatial and landscape ecology reveals that it also depends on spatial quality. This is because in many species the long-term persistence of a population depends on large-scale processes. In heavily exploited landscapes, the local presence and abundance of a species in the remaining fragments depends especially on the spatial cohesion of the habitat networks. In areas where the spatial cohesion drops below a critical threshold, the species will sooner or later disappear from those areas. Hence, a sustainable network requires suitable abiotic conditions and a minimal level (threshold) of habitat network cohesion.
Planning landscapes for nature should start, therefore, by planning the large scale green structures: ecological networks (Hanski 1999, Verboom *et al.*, 2001, Opdam 2002, Gutzwiller 2002, Opdam *et al.*, 2003).

What is an ecological network?
An ecological network is a network of habitat patches of a species. These habitat patches are in contact with each other by dispersal movements. When a local population in a patch becomes extinct, dispersing individuals coming from other patches in the network can recolonize the patch again. A sustainable habitat network is defined as a set of habitat patches of such size and coherence that the chance of extinction of the network population is smaller than 5% in 100 years.

An important concept for ranking options according to ecological efficiency is the key patch. This is a relatively large patch in a network, which is considered to exert a stabilizing effect on the dynamics of the network population. A key patch in a network increases the resilience of the population to network dynamics and disturbance. A network with a key patch therefore requires less area than a network without one, assuming equal habitat quality, patch density and matrix permeability (Figure 32).

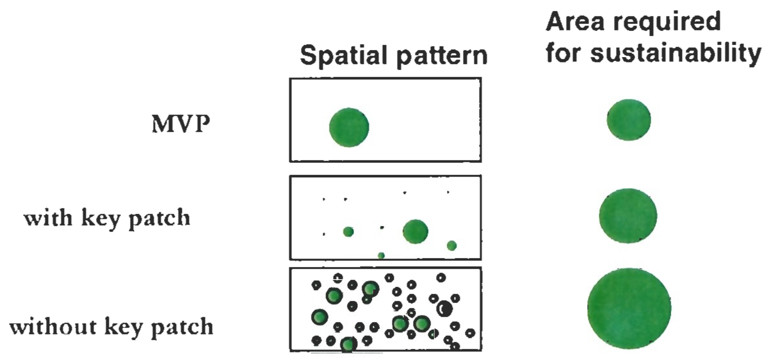


Figure 32 The required area for a viable population is larger as the habitat is more fragmented. A key area has a stabilising effect on a habitat population and diminishes considerably the minimum required area

How to improve ecological networks?
Network cohesion depends on four components:
- habitat quality
- network area
- network density
- matrix permeability

Any of these components may be improved to lift the network above the minimum cohesion threshold, and any combination will do as well. These four components offer alternative strategies to reach sustainability.

We defined the accepted chance of extinction of a network population at 5% in 100 years. This means that in order to reach a higher level of sustainability, it is recommended to link several networks together. Large areas, containing several populations that are viable on their own, may serve as a local network with lower risks.

Other arguments for linking locally sustainable networks (besides the 5% risk of local extinction) is that metapopulation ecology is not yet developed to the level that large scale risks such as climate change and pest outbreaks are accounted for in determining sustainability thresholds (Hanski 2001, Verboom *et al.*, 2001).

8.3 Generating and ranking alternative options

We identified those areas in which a sustainability level within the range of ambition set by Cheshire County Council could be reached.

Ecologically, network improvement options may vary:
- in the *amount of area* to be developed to attain sustainability
- in the limits and management costs to improve *habitat quality*
- in the *abiotic potential* of the landscape to develop ecosystem area at the right place, and
- in the necessity to develop *crossings with infrastructural barriers*

To generate alternative options, we used abiotic potential maps and transport infrastructure maps delivered by Cheshire County Council and also local expert knowledge about the actual quality of existing nature. We generated options by determining the amount of ha. of extra habitat and the required location of habitat to be developed to push a network into sustainability. This is considered the *minimal* required amount, assuming an average network density, removing barriers by installing adequate fauna passages, and assuming favourable habitat conditions. If these conditions are not met, extra habitat is required.

Although all generated options offer good conditions for the species of the selected ecoprofiles at the level of a network, some options offer better perspectives than others. This can be the result of differences in the situation of an improved network in relation to other networks or of the present or potential habitat quality. Based on this, we ranked ecologically the different options.

Alternative options also differ in social and economic opportunities. We used results from a stakeholder opinion analysis and information about likely future urban development and about future sites for mineral extraction and waste disposal to match the ecologically ranked options with the socio-economic opportunities.

The best choice is both ecologically adequate (which is not necessarily ecologically the best) and most favourable from the point of view of other land use interests.

8.4 Cheshire County ecological network planning: an open process with stakeholder involvement

We developed this vision by taking the steps that are presented in the table below (Table 49). In this table also indicates which team was mainly involved in the step, the project team of Alterra or of Cheshire County Council or both. The results of the last step, preparing an integrated vision of an ecological network, is described in the next paragraph.

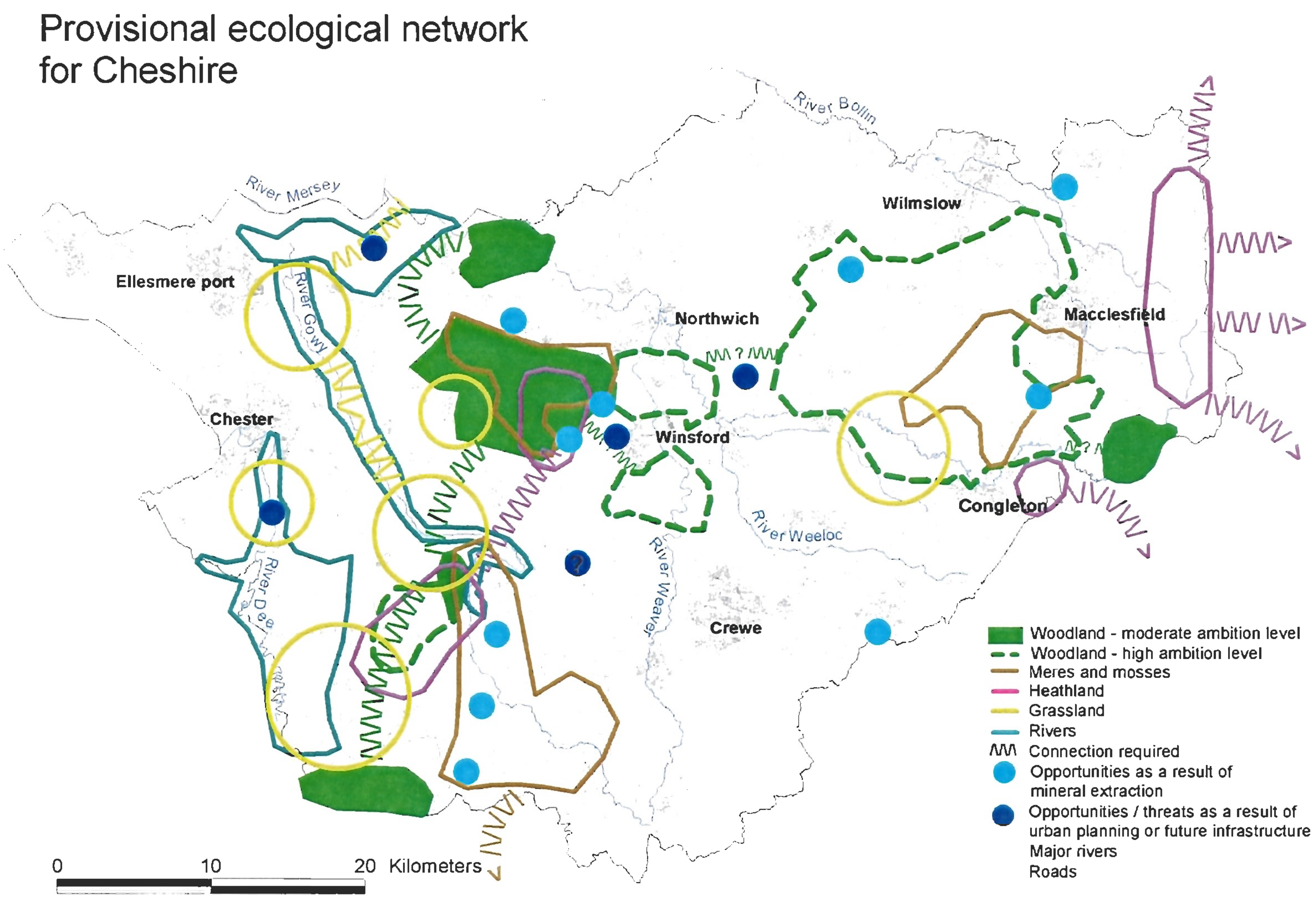


Figure 33 Provisional scenario for Cheshire County

Table 49 Steps involved in making a vision of an ecological network for Cheshire County. The table indicates which project team(s) was involved in each step

	Alterra	Cheshire County Council
1. a spatial analysis of the actual state of habitat cohesion for a series of species	X	
2. choosing target ecosystem types based on national, regional and county nature conservation policy priorities	X	X
3. indicating a minimum and a maximum ambition level in terms of defined area for nature		X
4. selecting target ecoprofiles	X	
5. selecting potential areas for habitat network improvement per ecosystem type resulting in a map per ecosystem, in which optional areas for improvement are indicated	X	
6. ranking these optional network areas by ecological criteria	X	
7. an enquiry among stakeholder groups to seek their opinion on the logic of the selected optional areas, and the potential for nature development of those areas		X
8. Confronting stakeholder expert opinion and urban/industrial development with the result of step 6, resulted in a rearrangement of selected network upgrading areas	X	X
9. combining the options per ecosystem into an integrated vision, in a cyclical process interacting with step 7	X	X

8.5 Integrated vision of Cheshire County Ecological Network

Priority landscape zone: in the west of Cheshire County

The most profitable long term conservation of Cheshire's preferred ecosystems appears to be the improvement of the landscape cohesion in the western half of the County, roughly in between Ellesmere Port, Northwich, Chester and Malpas (Figure 33). Parts of this zone are already designated for their special value for nature conservation. The development of this zone deserves the highest priority from the point of view of ecological effectiveness.

This zone contains a chain of interconnected woodland networks, alternating with two interconnected heathland networks and two isolated but locally sustainable peatland networks. The woodland and heathland networks can be linked to well-developed networks just across the border in Wrexham and Shropshire. It also contains priority areas for grassland development, particularly in the valley of the Gowy River. This river valley is therefore recommended as one of the most promising areas for nature development, and adds to the ecological potential of the zone. Another reason to include the Gowy River in the ecological network is the protection status of sections of this river valley. The River Dee and the tidal floodplain of the River Mersey are also protected by (inter)national directives. Because of the protected status of these rivers and their favourable location close to another, these rivers are chosen over the other river systems in the County.

The development of sustainable ecological networks in this zone will generate a landscape zone with a high density of natural ecosystems. This is favourable from the point of view of ecosystem management and protecting the areas from external disturbances. Also, the groundwater seepage areas on the slopes of the ridge are most favourable for developing high quality wet grassland ecosystems.

The landscape zone also offers a high potential from the point of view of leisure and human landscape perception. The margins and immediate surroundings of this zone will be attractive for small housing development in the higher price categories , as well as recreation activities. These should be regarded as potential sources for social and financial support in the locality. The presence of six potential sites for mineral extraction in the Delamere area and possible expansions of the power plant in the north may also be regarded as opportunities to finance the development of heathland and unimproved grassland habitats.

Secondary landscape zone: in the east of Cheshire County
Going further east, across a zone of urban and infrastructure development in mid-Cheshire, the Cheshire County ecological network has another core area around Macclesfield and Congleton. The networks recommended for improvement, a conglomerate of woodland landscape, peatland, heathland and grassland, also coincide with designated areas of special County value. This zone is less well connected with other networks (with exception of the heathland network) and the wooded area needs quite an investment to be upgraded to the required level of sustainability. Mitigation of infrastructure barriers is also needed. There is only one site of potential mineral extraction, whereas the expected expansion of Macclesfield means a potential problem to nature development in this zone. We regard this eastern landscape zone as promising, but less so in comparison to the western zone.

Linking the west Cheshire and east Cheshire landscape zones for extra robustness
To reduce potential risks of climate change and other large-scale disturbances, these two zones could be connected. This can be realised by increasing the density of woodland in the urban network to the west of the M6 motorway. In this zone it is expected that the urban sprawl will continue. This could be a reason to regard it as ecologically less promising. However, the development of robust greenways for the urban population, with a high density of woodland habitat and mixed with unimproved grassland, offers a great opportunity to link the east and west zones of the Cheshire County Ecological Network. The urban development offers an opportunity to finance a greenway with a strategic nature function (a unique selling point to the public) with urban money, including funds linked to the upgrading of the M6 motorway. It is recommended to insert this idea as early as possible into local and regional planning schemes, and try to reserve potential area at the right locations.

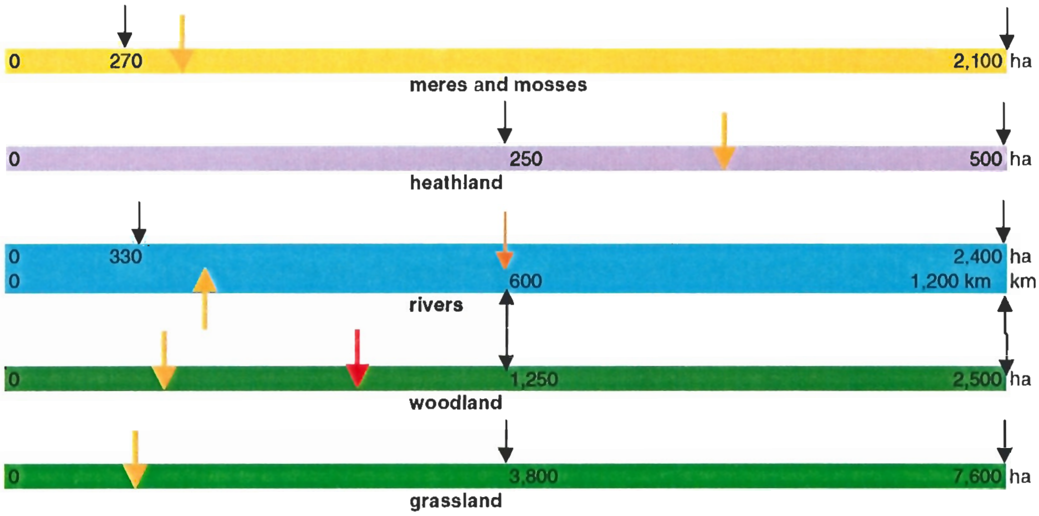


Figure 34 Area and lengths that are the minimum required for a sound ecological network for target ecoprofiles as proposed in Figure 33 (indicated with a red arrow). The minimum required area is related to the minimum and maximum ambition level, aspired by the County Council (black arrows). For 'woodland', 2 red arrows are indicated: one for the moderate ambitions level and one for the high ambition level (red). For 'rivers' the ambition levels for both area and length of natural banks are indicated. For the calculation of these values see annex 4.

The development of upland heathland in the Peak District National Park should be related to the development of the network in neighbouring Counties. This will be mainly a matter of habitat improvement, since the area is already quite large.

Required area and ambitions levels

For the proposed ecological network, some minimum investments in the development of ecosystems are required to make the network ecologically sound for species that fit in the target ecoprofiles (see annex 3). These minimum requirements in the development of extra areas or natural riverbanks are indicated in Figure 34. These figures should be interpreted as the 'best case scenario': exactly the required area in exactly the right places to achieve sustainable populations (see annex 4).

It appears that for heathland and river ecosystems, and also for meres and mosses, the minimum ambition level is only just exceeded. For woodland and grassland ecosystems, the minimum ambition levels are not even reached. This means that the ecological network, in the sense of investments in area, is within the aspiration level of the County. It also means that even with the present plan of investments in the expansion of woodland and grassland (minimal ambition level), sustainable conditions for species such as Barn owl and Dormouse can be realised.

The figures presented give an idea of the minimum area that is required. In the actual situation, the optimal configuration of habitat will not always be feasible, so more area will be needed. Realising more area for the ecosystem will also improve conditions for sustainable populations.

The areas in Figure 33 should be seen as search areas: realising nature development in these areas will result in a high ecological profit and good conditions for biodiversity in the County in the long term. Indications of requirements and design rules for habitat patches can be found in annexes 3, 5 and 6.

Use of this vision

We recommend using this vision as a guideline for making decisions in local and strategic planning in Cheshire County. Nature quality depends on cohesion at higher spatial scales than the usual scale at which decisions for spatial development are made. This vision could be used as a framework for co-ordinating local decision-making and be profitable for nature at the local level due to the large-scale cohesion visualised in this map.

Literature

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Appendix 1 Checklist required information stakeholders

Goal of interview:

1. Gain insight in the spatial developments of the interests of the stakeholder in Cheshire County.
2. Get to know the opinion of the stakeholder on ecological restoration of specific areas that can be part of an ecological network.

Content of interview:

- *Explanation of context and goal of a sound ecological network in Cheshire*

- *Sound out stakeholder on spatial developments in the County in the field of interest of stakeholder*

  What are spatial developments that stakeholder sees in Cheshire County in the field of his interest:
  - Are *decisions* made that will have an effect on the land use in the county? What will be the effect on the land use?
  - Do they know of any *intentions* or *tendencies* in the field of their interest that will have effect on the land use in the county?

If so:

- What do these decisions/intentions/tendencies exactly comprehend?
- In which specific area(s) can these decisions/intentions/tendencies be expected (indicate on map)?
- Are the mentioned intentions or tendencies *necessary* for the interest of the stakeholder (or of the people he represents), or are they *desirable*?

Output per stakeholder:

⇒ ***Overview of future developments in land use in Cheshire county and their nature (what kind of developments) and status (already decided or not, if not: necessary or desirable).***

⇒ ***Map of Cheshire County, on which the areas are indicated on which future developments will have their effect on the land use.***

- *Sound out what possibilities stakeholder sees for the development of ecosystem in specific areas*
  In the development of spatial options, a number of areas are selected that offer potential for a sound ecological network. These areas are prioritised.
  Check out the view of the stakeholder on the development of the original ecosystem on the selected sites: is the suggested development of the ecosystem within the point of view of the stakeholder:

  A positive: serves also his interest (+ / +)
  B no problem, doesn't effect his interest (+ / 0)

C can effect his interest, but solution can be found (+ / ±)
D effects his interests seriously: development is impossible (+ / -)

Important is to get to know and to put down the argumentation of their choice!

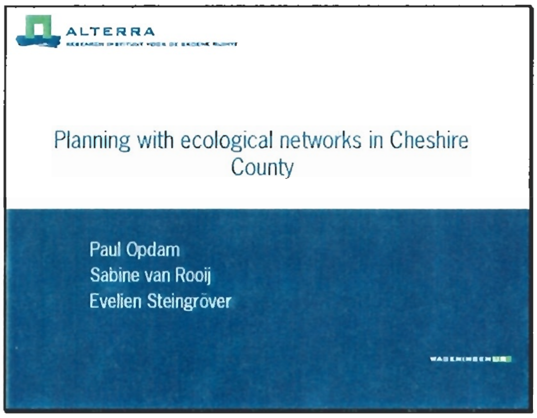
Output per stakeholder:

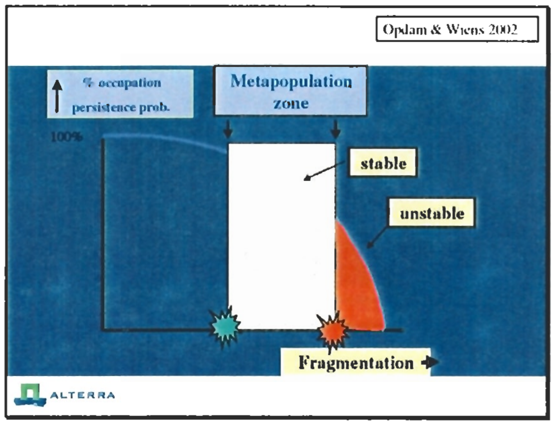
⇒ ***Overview of opinion on the restoration of suggested areas in an ecological network.***

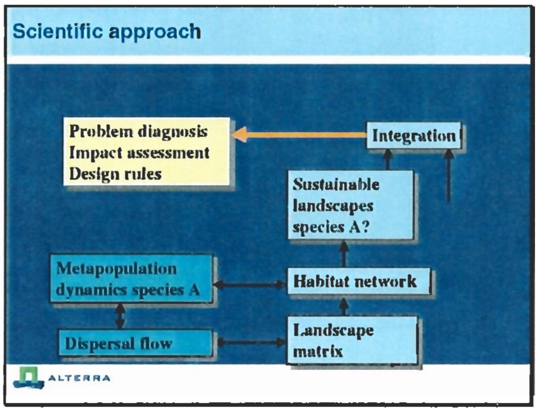
⇒ ***Argumentation of the opinion of stakeholders (per area; see table below).***

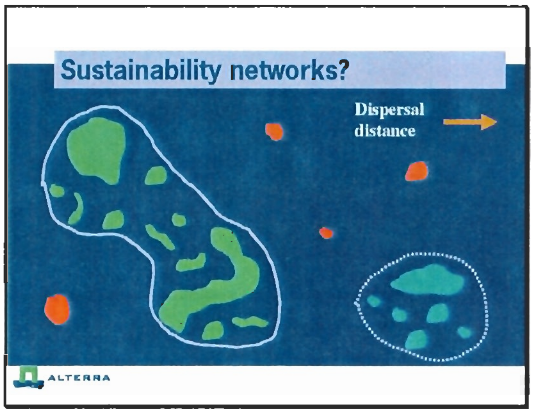
Stakeholder: (e.g. chairman agricultural union)					
	view of stakeholders Areas of interest	A: positive	B: no problem	C: solvable	D: impossible
Declining ecological profit ↓	Area network a (e.g. Delamere forest)	(e.g. unprofitable land)			
	Area network b (e.g. Gowy area)			(e.g.recreation has to be regulated, costs have to be compensated)	
	Area network c		arguments		
	Area network d				
	Area network e				arguments
	Area network f			arguments	
	Area network g	arguments			
	Area network h		arguments		
	Area network i	arguments			

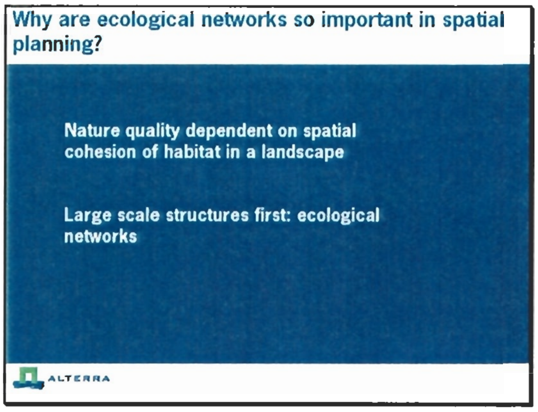
Appendix 2 Presentation workshop

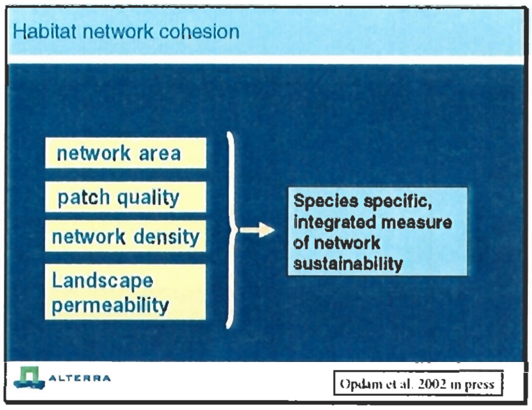


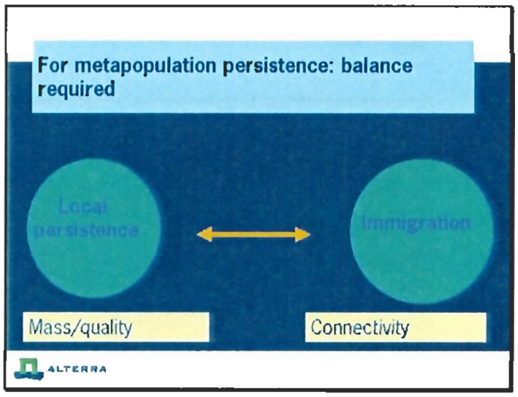


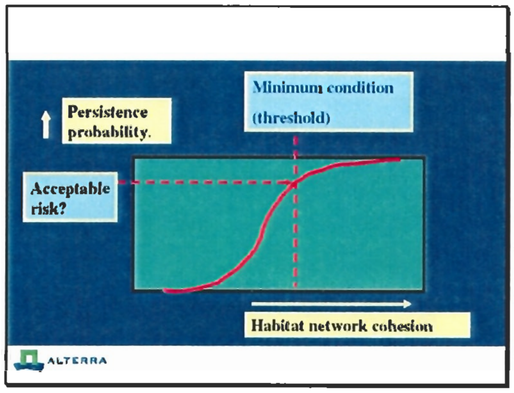


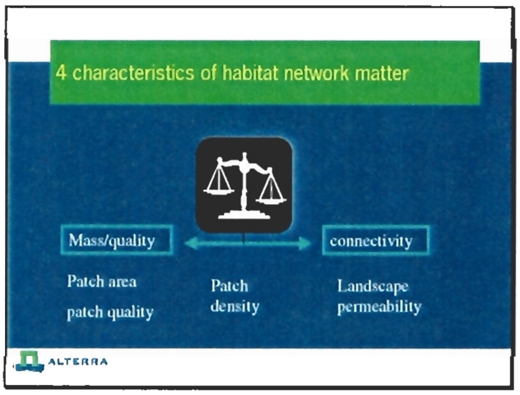


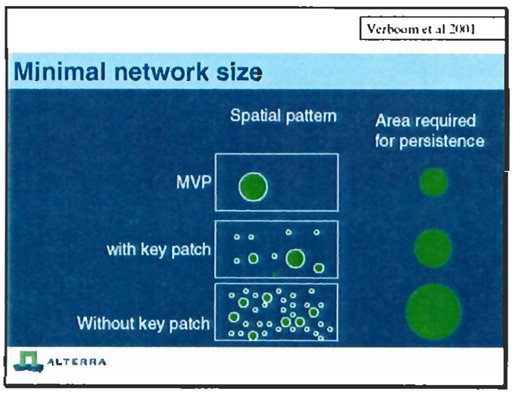

Why are ecological networks so important in spatial planning?
Nature quality dependent on spatial cohesion of habitat in a landscape
Large scale structures first: ecological networks
ALTERRA

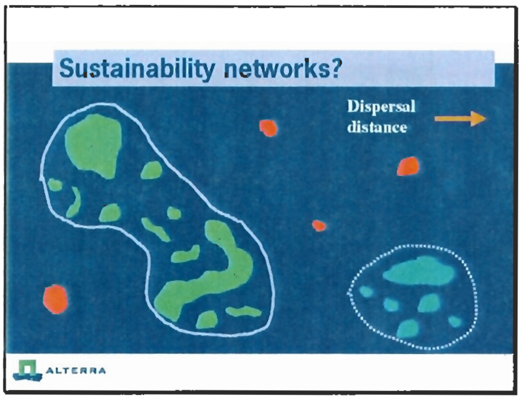

Habitat network cohesion
network area
patch quality
network density
Landscape permeability
Species specific, integrated measure of network sustainability
ALTERRA
Opdam et al. 2002 in press

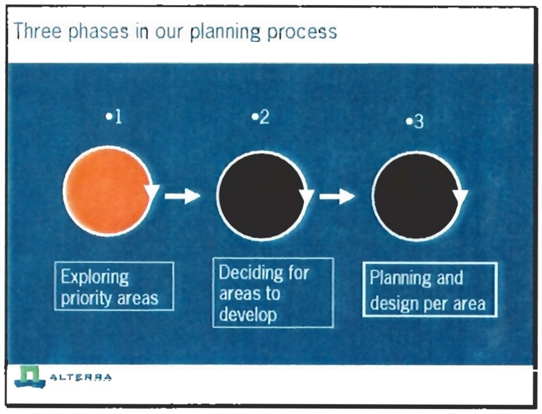

For metapopulation persistence: balance required
Local persistence
Immigration
Mass/quality
Connectivity
ALTERRA

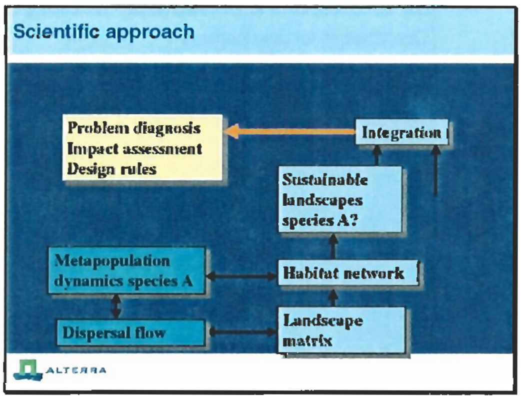

Persistence probability
Minimum condition (threshold)
Acceptable risk?
Habitat network cohesion
ALTERRA

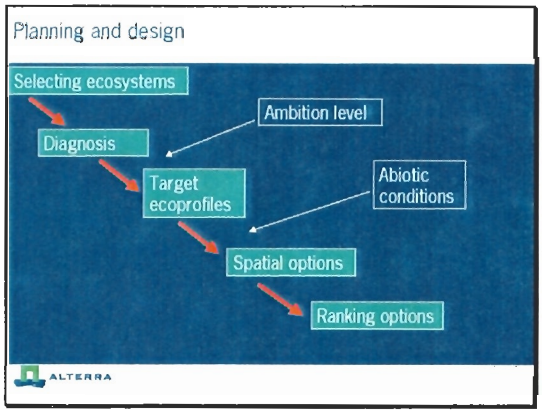

4 characteristics of habitat network matter
Mass/quality
connectivity
Patch area
patch quality
Patch density
Landscape permeability
ALTERRA

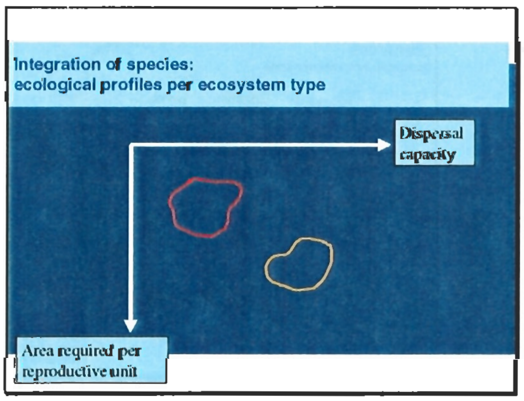

Verboom et al 2001
Minimal network size
Spatial pattern
Area required for persistence
MVP
with key patch
Without key patch
ALTERRA

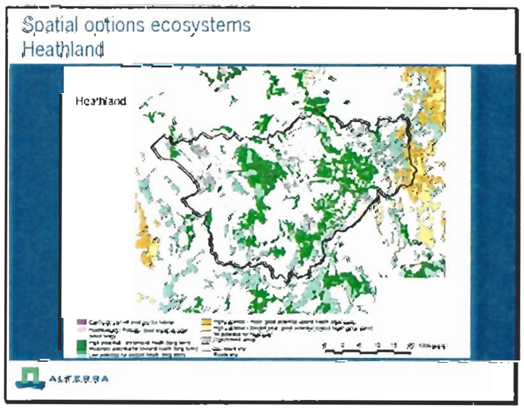

Sustainability networks?
Dispersal distance
ALTERRA

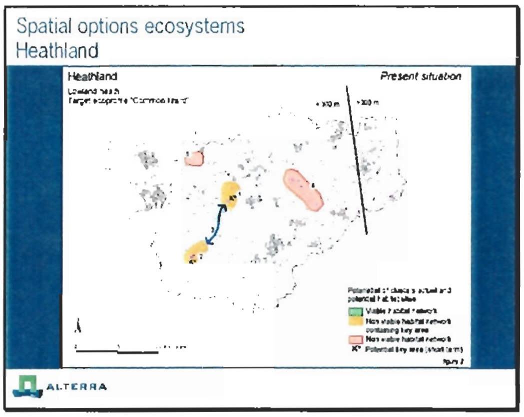

Three phases in our planning process
•1
•2
•3
Exploring priority areas
Deciding for areas to develop
Planning and design per area
ALTERRA


Scientific approach
Problem diagnosis
Impact assessment
Design rules
Integration
Sustainable landscapes species A?
Metapopulation dynamics species A
Habitat network
Dispersal flow
Landscape matrix
ALTERRA

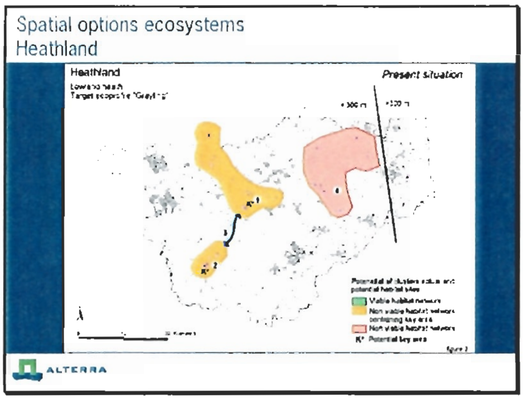

Planning and design
Selecting ecosystems
Ambition level
Diagnosis
Target ecoprofiles
Abiotic conditions
Spatial options
Ranking options
ALTERRA

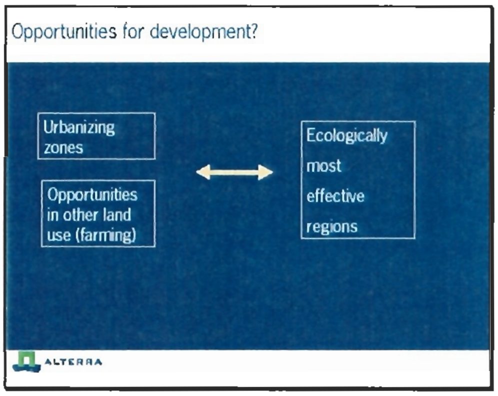

Integration of species:
ecological profiles per ecosystem type
Dispersal capacity
Area required per reproductive unit

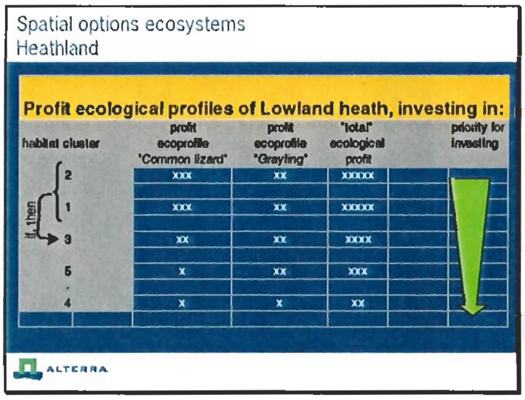

Spatial options ecosystems
Heathland
Heathland
ALTERRA

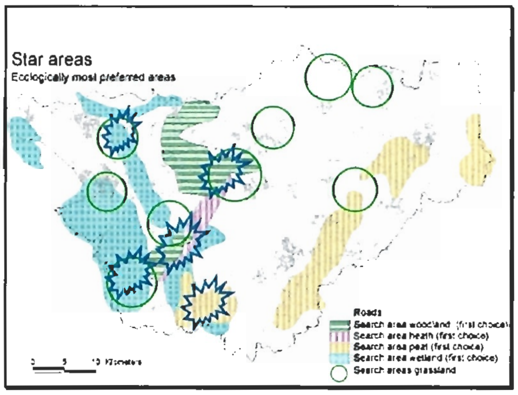

Spatial options ecosystems
Heathland
Heathland
Present situation
ALTERRA

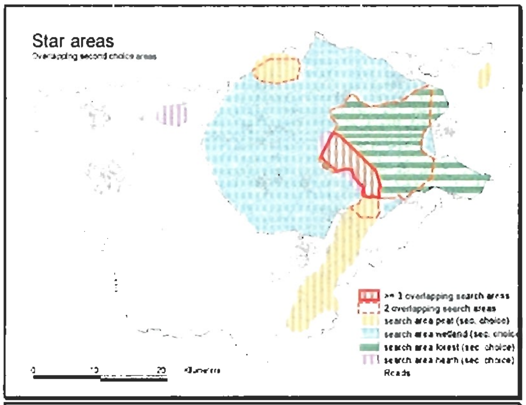

Three phases in our planning process
•1
•2
•3
Exploring priority areas
Deciding for areas to develop
Planning and design per area
ALTERRA

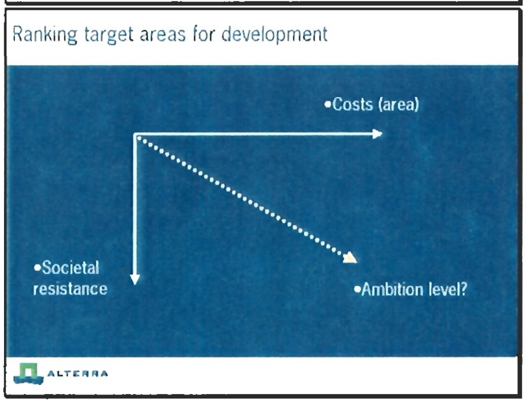

Spatial options ecosystems
Heathland
Heathland
Present situation
ALTERRA

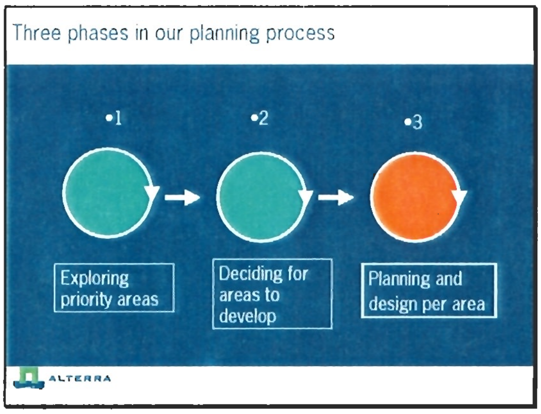

Opportunities for development?
Urbanizing zones
Opportunities in other land use (farming)
Ecologically most effective regions
ALTERRA


Spatial options ecosystems
Heathland
Profit ecological profiles of Lowland heath, investing in:
habitat cluster
profit ecoprofile 'Common lizard'
profit ecoprofile "Grayling"
"total" ecological profit
priority for investing
if, then
2 xxx xx xxxxx
1 xxx xx xxxxx
3 xx xx xxxx
5 x xx xxx
4 x x xx
ALTERRA


Star areas
Ecologically most preferred areas

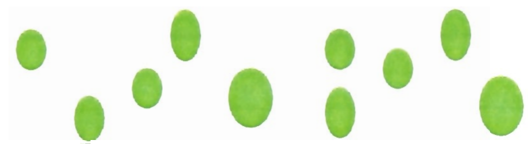
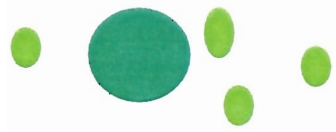
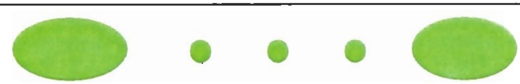

Star areas
Overlapping second choice areas
2 overlapping search areas
search area peat (sec. choice)
search area forest (sec. choice)
Roads
0
10
20


Ranking target areas for development
•Costs (area)
•Societal resistance
•Ambition level?
ALTERRA


Three phases in our planning process
•1
•2
•3
Exploring priority areas
Deciding for areas to develop
Planning and design per area
ALTERRA

Appendix 3 Requirements for sustainable networks in Cheshire

The requirements for creating viable networks and/or key populations in are summarised in the table on the next page.
This table should be interpreted as follows:

	Explanation	Schematic image	remarks
Area viable network (without key area):	cluster of habitat patches within dispersal distance of each other, large enough to sustain a viable population of a species of an specific ecoprofile		The area indicated in the next table indicates the minimal total area of separate habitat patches within dispersal distance of each other, that is required for viable populations of species of a specific ecoprofile.
Area viable network (including key area):	cluster of habitat patches, including a key area, within dispersal distance of each other, large enough to sustain a viable population of a species of an specific ecoprofile		The area indicated in the next table indicates the minimal total area of separate habitat patches within dispersal distance of each other, that is required for viable populations of species of a specific ecoprofile. A network with a key area is more resilient than one without.
Key area	a habitat patch with a carrying capacity large enough to sustain a relatively large population of a species of an specific ecoprofile, which is persistent under the condition of one immigrant per generation		The area indicated in the next table indicates the minimal area that is required for a key population of species of a specific ecoprofile.
Dispersal distance	Distance that most individuals of a species (80%) can bridge to new, potential habitat. Habitat patches situated within this distance from each other are part of the same habitat network		The dispersal distance is required to distinguish separate habitat networks in a landscape.
Area stepping stone	Minimum required habitat area for 'stepping stones' that can bridge a distance between different habitat networks (see also annex 4)		First you have to wonder if the species you are aiming at use stepping stones (see annex 4).

Ecosystem	Meres and mosses	Heathland		Rivers and floodplains		Woodland		Grassland	
Ecoprofile	**Green hairstreak**	**Common lizard**	**Grayling**	**Water vole**	**Sedge warbler**	**Dormouse**	**Marshtit**	**Common blue**	**Barn Owl**
Area viable network (including key area)	250 ha	75 ha	125 ha	80 km	400 ha	150 ha	450 ha	50 ha	80 territories, of which 20 adjoining territories
Area viable network (without key area)	250 ha	125 ha	125 ha	100 km	600 ha	200 ha	600 ha	50 ha	120 territories
Key area[4]	100 ha[5]	25 ha	50 ha	Length of habitat along watercourse: 40 km[6]	100 ha[7]	100 ha	300 ha	20 ha[8]	20 adjoining territories[9]
Dispersal distance	5 km	1 km	5 km	3.2 km	10 km	1.5 km	11 km	0.300 km	50 km
Sensitive to barriers	no	yes	no	yes	no	yes	no	yes	no
Area stepping stone		3 ha				-	30		

[4] Habitat of a key area should be more or less adjoining
[5] Distance between habitat patches in an key area may not exceed 500 m
[6] Habitat along the river may not be interrupted more than 250 m
[7] Habitat along the river may not be interrupted more than 200 m
[8] Distance between habitat patches in an key area may not exceed 250m
[9] distance between territories may not exceed 5 km; 1 territory = at least 50 ha of rough grassland within an area of 300 - 1,000 ha

Appendix 4 Minimal required area in vision on ecological networks

In the tables below, calculations are shown of the area that is *minimal* required to realise the presented vision on ecological networks in Cheshire. The objectives that can be achieved by creating extra habitat are also defined.
In this calculation, it is assumed that all the spatially most effective areas are available for nature development. In real life, this will not be the case. That means that in practice, more area is needed to realise the same objectives than the areas presented below. The figures are calculated to get an *impression* of the required areas for nature development and to relate them to the ambitions of the county council.

Ecosystem	**meres and mosses:**			
area:	**habitat:**		**required for:**	**remarks:**
Delamere forest	actual present	135 ha		(calculated with GIS)
	potential present	215 ha		(calculated with GIS)
	required	100 ha	for key area	
		250 ha	for a sustainable network including a key area	
	added to present situation:	80 ha	for key area and maximal extra habitat	
Peckforton	actual present	41 ha		(calculated with GIS)
	potential present	176 ha		(calculated with GIS)
	required	100 ha	for key area	
		250 ha	for a sustainable network including a key area	
	added to present situation:	135 ha	for a sustainable network including a key area	
Gowy marshes		50 ha		
Area in east of Cheshire	actual present	140 ha		(calculated with GIS)
	potential present	471 ha		(calculated with GIS)
	required	100 ha	for key area	
		250 ha	for a sustainable network including a key area	
	added to present situation:	110 ha	for a sustainable network including a key area	
total	added to present situation:	375 ha		

Ecosystem	heathland:			
area:	**habitat:**		**required for:**	**remarks:**
Delamere forest	actual present	5 ha		(calculated with GIS)
	potential present	51 ha		(calculated with GIS)
	required	50 ha	for key area	
		125 ha	for a sustainable network including a key area	
	added to present situation:	**120** ha	for a sustainable network including a key area	
Peckforton	actual present	14 ha		(calculated with GIS)
	potential present	91 ha		(calculated with GIS)
	required	50 ha	for key area	
		125 ha	for a sustainable network including a key area	
	added to present situation:	**111** ha	for key area and maximal extra habitat	
Stepping stones	actual present	0 ha		(calculated with GIS)
	potential present	? ha		
	required	100 ha	11 km have to be brigded with stepı ha	
	added to present situation:	**100** ha	assumed that suitable habitat can be realised	
Area in east of Cheshire	actual present	14 ha		(calculated with GIS)
	potential present	25 ha		(calculated with GIS)
	required	50 ha	for key area	
		125 ha	for a sustainable network including a key area	
	added to present situation:	**36** ha	key area (supplementary habitat for sustainable network is present across the county border)	
total	added to present situation:	**367** ha		

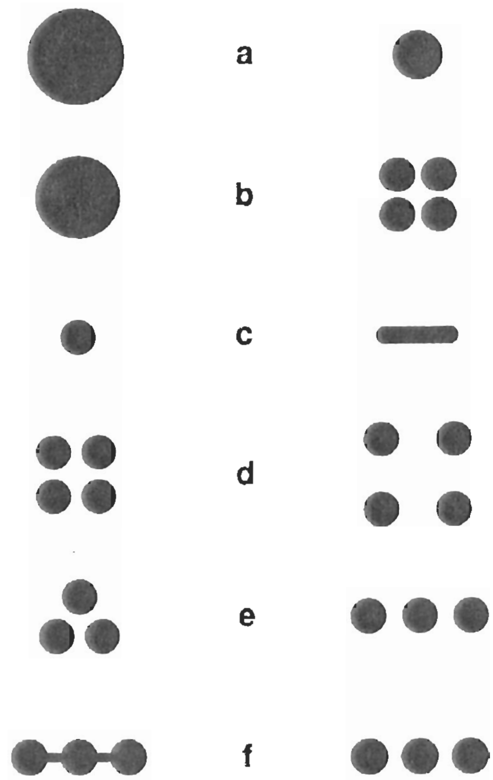
Ecosystem	Woodland				
area:	**habitat:**			**required for:**	**remarks:**
		[grey box]		= low ambition level	aimed is for ecoprofile dormouse
		[grey box] + [outlined box]		= higher ambition level	aimed is for ecoprofile dormouse and marshtit
North of delamere forest					
	actual present	187	ha		(calculated with GIS)
	required	100	ha	for key area	for ecoprofile dormouse
		150	ha	for a sustainable network including a key area	for ecoprofile dormouse
		50	ha	for key ; key population dormouse	(calculated with GIS)
		16		corridor	16km*10m
	added to present situation:	66			
Corridor between area north of Del. Forest and delamere forest	actual present	82	ha		(calculated with GIS)
	required	25	ha	corridor	2*12km*10m
	added to present situation:	25	ha		
Delamere forest	actual present	45	ha		broadleaf forest and mixture
		470	ha		coniferous forest that should be turned into broadleaved forest
	required	150		for a sustainable network including a key area	for ecoprofile dormouse
	added to present situation:	115		for a sus key population and aanvullend habitat for	for ecoprofile dormouse
areas east of Delamere	actual present	400	ha		(calculated with GIS)
	required	600	ha	two key areas	for ecoprofile marshtit
	added to present situation:	200	ha	for enlarging and connecting habitat patches	
Peckforton	actual present	90	ha		(calculated with GIS)
	required	150	ha	for a sustainable network including a key area	for ecoprofile dormouse
	added to present situation:	60	ha	for a sustainable network including a key area	
extended area Peckforton	actual present	150	ha		(calculated with GIS)
	required	300	ha	for key area	for ecoprofile marshtit
	added to present situation:	150	ha	for key area	for ecoprofile marshtit (sufficient supplementarry habitat is present in the surroundings for a sustainable habitatnetwork)
corridor between that area and Peckforton	actual present	0	ha		(calculated with GIS)
	required	32	ha	corridor for the dormouse	2 * 16km * 10 m
	added to present situation:	32	ha	corridor for the dormouse	
area south of Peckforton	actual present	60	ha		(calculated with GIS)
	required	150	ha	for a sustainable network including a key area	for ecoprofile dormouse
	added to present situation:	90	ha	for a sustainable network including a key area	for ecoprofile dormouse
area in east of Cheshire	actual present	150	ha		(calculated with GIS)
	required	300	ha	for key area	for ecoprofile marshtit
	added to present situation:	150	ha	for key area	
total	added to present situation:	388	ha		
total	added to present situation:	888	ha		

Ecosystem	rivers				
area:	**habitat:**			**required for:**	**remarks**
River Dee	required	400	ha	for a sustainable network including a key area	for ecoprofile sedge warbler
		80	km	for a sustainable network including a key area	for ecoprofile water vole
	added to present situation:	**400**	ha	for a sustainable network including a key area	for ecoprofile sedge warbler
		80	km	for a sustainable network including a key area	for ecoprofile water vole
River Gowy	required	400	ha	for a sustainable network including a key area	for ecoprofile sedge warbler
		80	km	for a sustainable network including a key area	for ecoprofile water vole
	added to present situation:	**400**	ha	for a sustainable network including a key area	for ecoprofile sedge warbler
		80	km	for a sustainable network including a key area	for ecoprofile water vole
floodplain in north	required	400	ha	for a sustainable network including a key area	for ecoprofile sedge warbler
		80	km	for a sustainable network including a key area	for ecoprofile water vole
	added to present situation:	**400**	ha	for a sustainable network including a key area	for ecoprofile sedge warbler
		80	km	for a sustainable network including a key area	for ecoprofile water vole
total	added to present situation:	**1200**	ha	wetland	
total	added to present situation:	**240**	km	natural bank	

Ecosystem	grassland				
area:	**habitat:**			**required for:**	**remarks**
	required	20*50	ha	for a sustainable network	for ecoprofile barn owl
	present on indiated areas	100	ha		
	added to present situation:	**900**	ha	for a sustainable network	for ecoprofile barn owl
total	added to present situation:	**900**			

Appendix 5 Design rules for habitat patches

Habitat patches can have all sort of shapes. Designing new habitat patches, some shapes are more profitable for most species than others. In the figure below, rules for design are presented, based on the 'island biogeography'. For each rule, the design on the left is seen as superior to the alternative on the right.



Appendix 6 Minimum requirements fauna corridors

Source: Broekmeyer & Steingröver, 2001. Figures are tailored to the Dutch situation.

Ecoprofile	Width dispersal corridor	Minimum width corridor	Explanation
Amphibians			
All ecoprofiles	25 m	15 m	- Wet corridors: width equals width of watercourse, including banks and minimal 5 m wide dry strips on both sides - Dry corridors: minimal width 15 m
Reptiles			
Adder Smooth snake Slow worm Common lizard	25 m	15 m	
Grass snake	25 m	15 m	- Wet corridors: width equals width of watercourse, including banks and minimal 5 m wide dry strips on both sides - Dry corridors: minimal width 15 m
Mammals			
European harvest mouse	25 m		
Tundra vole European water shrew	25 m		- width of a combined wet-dry corridor equals width of watercourse, including banks and minimal 5 m wide dry strips on both sides
Beaver Otter	50 m	Watercourse + 5 m on both sides	- width of a combined wet-dry corridor equals width of watercourse, including banks and minimal 5 m wide dry strips on both sides
Squirrel	25 m	15 m	
Pine marten Badger Red deer	 100 m 1000 m	 50 m 200 m	
Butterflies			
All ecoprofiles that are sensitive for barriers	25 m	15 m	

Stepping stones
First you have to wonder if the species you are aiming at use stepping stones. Most flying species (e.g. butterflies and birds) or species with a large dispersal capacity (e.g. pine marten, roe deer) do.

Guideline area stepping stones: 10% of key area (and not less than 1 ha)