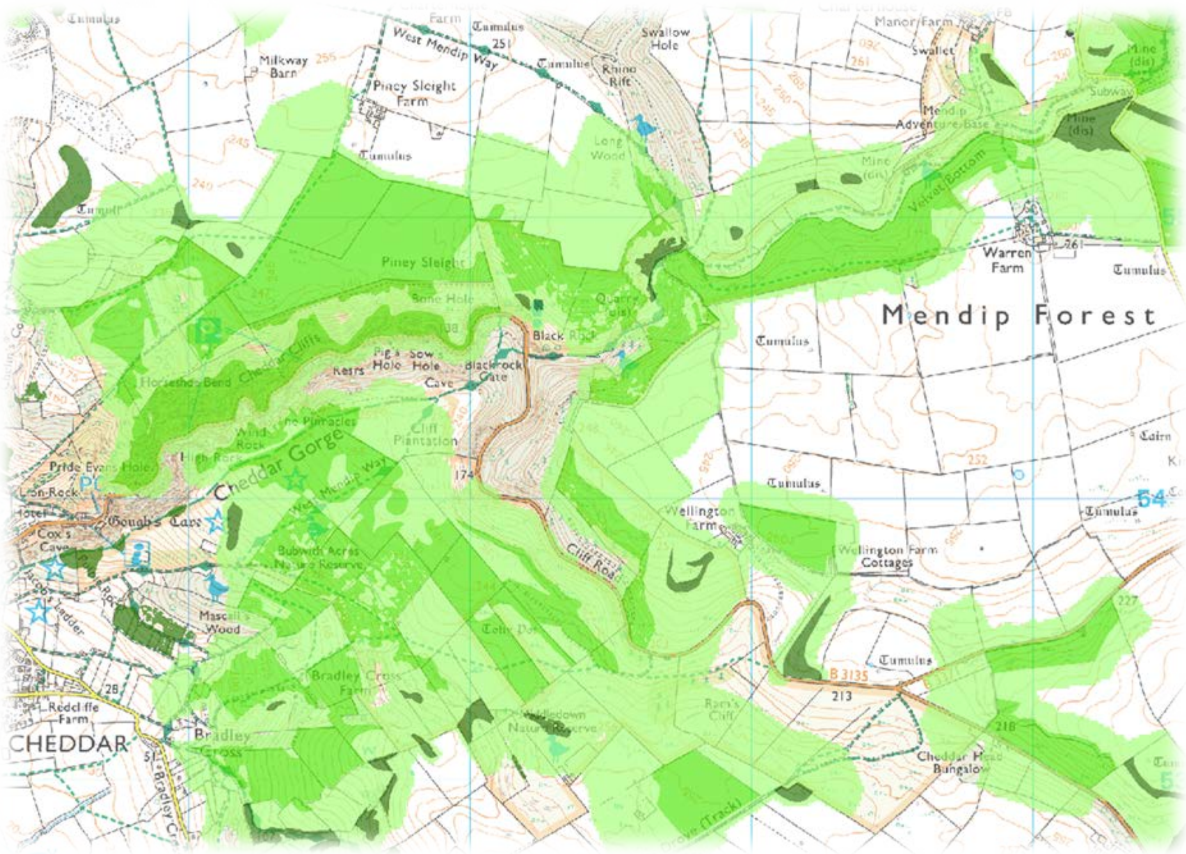
Somerset's Ecological Network

Mapping the components of the ecological network in Somerset



2016 Report

This report was produced by Michele Bowe, Eleanor Higginson, Jake Chant and Michelle Osbourn of Somerset Wildlife Trust, and Larry Burrows of Somerset County Council, with the support of Dr Kevin Watts of Forest Research. The BEETLE least-cost network model used to produce Somerset's Ecological Network was developed by Forest Research (Watts et al, 2010). GIS data and mapping was produced with the support of Somerset Environmental Records Centre and First Ecology

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Front Cover: Broadleaved woodland ecological network in East Mendip

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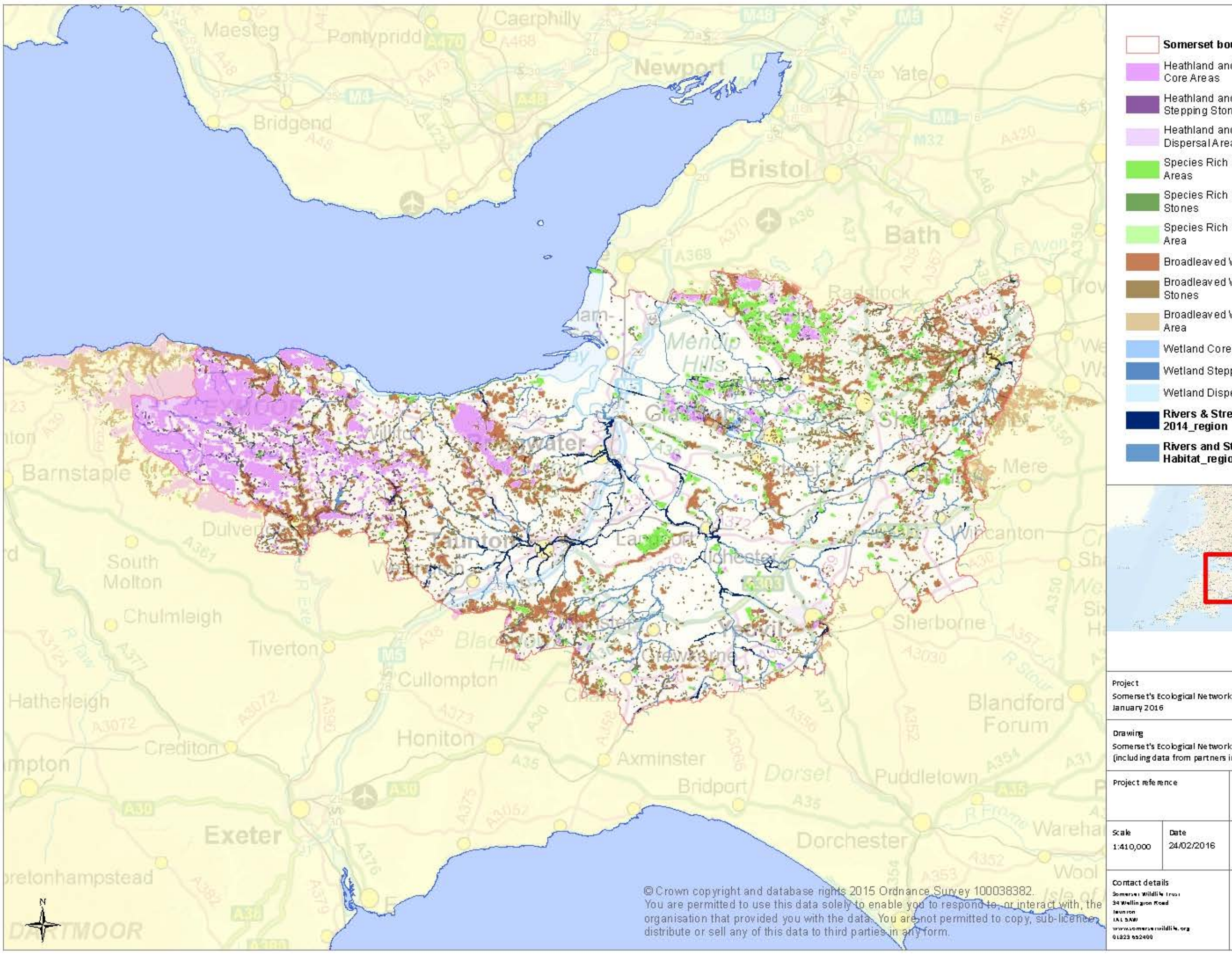
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Somerset's Ecological Network Summary

As part of their efforts to tackle the on-going biodiversity decline in England, the coalition Government instituted reforms to the planning system which seek to embed ecological sustainability into the strategic planning and development management processes. Substantive changes have been made to the requirements placed on Local Planning Authorities to plan for nature through the National Planning Policy Framework, which mandates Local Planning Authorities to plan strategically for nature, identifying and mapping ecological networks in order to deliver the protection, enhancement and maintenance of biodiversity.

Ecological networks are the basic, joined up infrastructure of existing and future habitat needed to allow populations of species and habitats to survive in fluctuating conditions. As a short term benefit, a landscape that species can move through easily allows recolonisation of areas after disturbance events, preventing local extinctions. In the long term, as our climate begins to change, well connected habitats offer opportunities for populations to move as conditions become more or less suitable. The movement of individuals between populations in a connected landscape maintains genetic diversity which allows populations to adapt to future changes in environmental conditions.

In this document a set of ecological networks have been produced for four broad habitat types in Somerset: Broad-leaved Woodland; Priority Grasslands (including calcareous, acid and neutral grassland); Heathland and Acid Grassland; and Fen, Marsh and Swamp. The networks were created using the BEETLE least-cost network model (Watts *et al*, 2010) with the parameters of the model based on the requirements of Somerset Priority Species for the minimum area needed to maintain a healthy population and typical dispersal distances.

The maps presented in this document represent components of Somerset's Ecological Network and should be viewed in combination with data relating to other elements of the landscape that are likely to influence the functioning and resilience of the ecological network.

The ecological networks mapped are fragments of what was once a much larger network, and as a minimum every effort should be made to maintain what remains in line with national and locally adopted policy. Recommendations have been made to suggest ways in which land use can be modified to complement the networks and increase the permeability of the landscape between networks.

Somerset's ecological network will continue to be updated as new data becomes available that will contribute to the mapping and evaluation of the networks currently identified.

1. Introduction

The Government White Paper on the Natural Environment, '*The Natural Choice: securing the value of nature*' published in June 2011 emphasises a need for a more strategic and integrated approach to planning for nature, which guides development to the right location and enhances natural networks. It states that '*The planning system will continue to facilitate coherent and resilient ecological networks in association with local partners… We want the planning system to contribute to our objective of no net loss of biodiversity*.' In order to realise the aspirations of the White Paper, the requirements for local authorities to act strategically for nature conservation has been embedded in The National Planning Policy Framework[1], which mandates planning authorities to '…*identify and map components of the local ecological networks…'*

Ecological networks are '…*A coherent system of natural and/or semi-natural landscape elements that is configured and managed with the objective of maintaining or restoring ecological functions as a means to conserve biodiversity*…' (Bennett, 2004)

'The ecological network is the basic infrastructure that will enable biodiversity assets to recover from deficit and become resilient to climate change impacts, and thus deliver ecosystem services which are of social and economic value.'[2] Maintaining and improving habitat connectivity is important in ensuring the long-term survival of biodiversity in a fragmented landscape and with a changing climate.[3]

Somerset's Ecological Network is a response to Government targets for the halting of biodiversity loss and safeguarding of ecosystems goods and services, and is a means of identifying the basic ecological infrastructure required to achieve this. Somerset's Ecological Network identifies the remaining areas of priority habitat, areas for biodiversity enhancement, and the connections that need to be made to link these areas up across the landscape.

Like all counties, Somerset has a range of development pressures including transport and energy infrastructure, housing growth, and minerals extraction, all of which must be balanced against a statutory requirement for nature conservation. Somerset's Ecological Network is a tool to assist with strategic planning and development management, ensuring that a growth agenda brings positive contributions to the restoration of the natural

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1 http://www.communities.gov.uk/publications/planningandbuilding/nppf
2 http://www.publications.parliament.uk/pa/cm201011/cmpublic/localism/memo/loc163.htm
3 http://jncc.defra.gov.uk/page-4249

environment, and benefits people in line with the Natural Environment White Paper and the National Planning Policy Framework.

The ecological network mapping carried out in GIS will show the extent of habitat networks in Somerset and aid identification of areas which need to be restored to improve function and resilience of the networks. It will serve as an evidence base for identifying where development could affect an ecological network by causing further fragmentation or the loss of key sites within the network. Somerset's Ecological Network will also eventually guide habitat creation and restoration resulting from Somerset's Habitat Evaluation Procedure.

2. Policy and Legislative Background to Ecological Networks

Introduction

Ecological Networks need to be implemented strategically, rather than on a piecemeal basis, in order to be effective, and therefore it is essential that they are planned for and delivered via the planning system, as well as other land use systems. Local authorities can clearly demonstrate that they are delivering their biodiversity duties as outlined in the Conservation of Habitats and Species Regulations 2010 and the Natural Environment and Rural Communities Act 2006 through the inclusion of ecological networks in relevant policy documents.

Government White Paper on the Natural Environment

The Government White Paper on the Natural Environment, 'The Natural Choice: Securing the Value of Nature', published in June 2011, includes provision for ecological networks in the planning system, stating an ambition to'…*create a resilient and coherent ecological network at a national and a local level across England*'.

The White Paper sets out the need for a '…*more strategic and integrated approach to planning for nature within and across local areas, one that guides development to the best locations… and enables development to enhance natural networks*…'. It also states that, '*The planning system will continue to facilitate coherent and resilient ecological networks, with local partners*…' and that the '… *planning system contributes to our objective of no net loss*.'

National Planning Policy Framework

The National Planning Policy Framework (Department for Communities and Local Government, 2012) [NPPF] sets out the Government's policy for biodiversity in the planning system. It states that as part of sustainable development a situation of no net loss for biodiversity is moved to one of net gains and sets out a core principle of contribution to, and enhancement of, the natural environment.

It states that '*Planning policies and decisions must reflect and where appropriate promote relevant EU obligations and statutory requirements*.' This would include the provisions of the Birds and Habitats Directives.

The NPPF states that, '*The planning system should contribute to and enhance the natural and local environment by, … minimising impacts on biodiversity and providing net gains in biodiversity where possible, contributing to the Government's commitment to halt the overall* *decline of biodiversity, including establishing coherent ecological networks that are more resilient to current and future pressures*.'

It also states that, '*Local planning authorities should set out a strategic approach in their Local Plans, planning positively for the creation, protection, enhancement and management of networks of biodiversity and green infrastructure*.'

The Framework specifically states that local planning policies should:

- **Plan for biodiversity at a landscape-scale** across local planning authority boundaries;
- **Identify and map components of the local ecological networks**, including: international, national and locally designated sites of importance for biodiversity[4], wildlife corridors and stepping stones that connect them and areas identified by local partnerships for habitat restoration or creation.
- Promote the preservation, restoration and re-creation of priority habitats, **ecological networks** and the protection and recovery of priority species populations, linked to national and local targets; and identify suitable indicators for monitoring biodiversity in the plan.

The Habitats and Birds Directives

Both Article 3 and Article 10 of the European Birds and Habitats Directives respectively[5] make reference to improving the 'ecological coherence' of that series of sites. For a site to be ecologically 'coherent' it needs to have links outside its designated area, in order to ensure that all habitats and species can be maintained in favourable conservation status in the long term.

Article 10 of the Habitats Directive requires member states to: '…*endeavour, where necessary, in their land use planning and development policies, and with a view to improving the ecological coherence of the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora. Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as*

[4] Within Somerset's Ecological Network international, national and locally designated sites of importance for biodiversity are not shown separately but will often be included by default as core areas due to the habitats for which they are designated.

[5] Council Directive 92/43/EEC on the Conservation of Natural Habitats and Wild Fauna and Flora (Habitats Directive) and Council Directive 2009/147/EEC on the Conservation of Wild Birds (Birds Directive).

stepping stones (such as ponds or small woods) are essential for the migration, dispersal and genetic exchange of wild species.'

Article 3 of the Birds Directive clearly makes reference to the need to undertake conservation actions outside of designated sites: '*The preservation, maintenance and re-establishment of biotopes and habitats shall include the following measures: (b) upkeep and management in accordance with the ecological needs of habitats inside and outside the protected zones*'.

A European Commission paper considers that 'Favourable Conservation Status' can be described as a situation where a habitat type or species is prospering (in both quality and extent/population) and with good prospects to so in the future as well. (Kuttunen et al, 2007)

The Habitats Directive sets out the requirements for the protection of species of Community interest, listed under Annex II, IV and/or V[6]. These European Protected Species (EPS) are required to be maintained at 'favourable conservation status' (FCS), which is defined as when:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

In addition Article 6(1) requires measures that '… *integrate SACs with a wider land use planning context in order to meet the '…*ecological requirements of the natural habitat types in Annex I and the species in Annex II present on the sites*'. There is a clear requirement to move beyond constraint mapping and incorporate explicit ecological requirements in the spatial planning process. As one of the key requirements is movement, i.e. migration, dispersal and genetic exchange, ecological networks could make a significant contribution to meeting this requirement.*' (Catchpole, 2006).

[6] Annex IV species are defined as 'animal and plant species in need of strict protection.' Annex II species are those for whose conservation require the designation of Special Areas of Conservation (SAC). Any potential impacts affecting the integrity of a SAC, including those designated for Annex II species, are required to undergo an 'Appropriate Assessment'. Annex V species are 'Animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures' which are likewise required to be maintained at 'Favourable Conservation Status'.

The Conservation of Habitats and Species Regulations 2010

The Conservation of Habitats and Species Regulations 2010 (the 'Habitats Regulations') transposes the provisions of the Habitats Directive into English legislation.

Regulation 9(5) requires that all public bodies have regard to the requirements of the Habitats Directive when carrying out their functions. This would include the provisions of Article 10 of the Habitats Directive.

Regulation 39 states that: '*For the purposes of the planning enactments mentioned below (the Town and Country planning acts), policies in respect of the conservation of the natural beauty and amenity of the land shall be taken to include policies encouraging the management of features of the landscape which are of major importance for wild flora and fauna*.'

The Natural Environment and Rural Communities Act 2006

Under s40 of the Natural Environment and Rural Communities Act (NERC), local authorities are legally required to '… *have regard, so far as is consistent with the proper exercise of those functions, to the purpose of conserving biodiversity*.'

Section 41 of the Act lists the species and habitats of principle importance in the conservation of biodiversity in England. The S41 list is used to guide decision-makers such as public bodies, including local and regional authorities, in implementing their duty under section 40, to have regard to the conservation of biodiversity in England, when carrying out their normal functions.

3. Habitat Connectivity and Fragmentation

Introduction

Habitats have undergone considerable loss and fragmentation through human activity. Further habitat loss and fragmentation is regarded as a serious threat to biodiversity conservation as it restricts the necessary movement of species across the landscape (Hanskii, 1999). This movement is essential for maintaining genetic variation in populations and for allowing recolonsation of habitats after local extinctions. Species also need to be able to move freely through the landscape to access resources as these can be scattered between habitat patches.

Biodiversity decline is likely to be compounded by climate change as many species will need to adjust. The fragmented nature of habitats in the landscape may seriously inhibit this range adjustment and prevent species movement (Watts et al, 2008).

Habitat Patches

A habitat patch is an area of distinct habitat which is used by a species. Habitat patches can vary in the role they play in the ecology of a species, for example some may be used for breeding whilst others are used for foraging. The maintenance of species and the ecological functionality of landscapes are determined by the role that different patches of habitat play for different species (Kuttunen et al, 2007).

Species are dependent on the existence of adequate habitat patches and the ability to disperse amongst them. It is important that the area and quality of available patches is sufficient to maintain a population that is large enough prevent inbreeding (Kuttunen et al, 2007).

Habitat patches are often spread across a large geographical area, meaning that each patch of habitat can be located a considerable distance from other patches (Scottish Natural Heritage, 2010).The area in between habitat patches is referred to as the habitat matrix (Kuttunen et al, 2007).

Conditions are not constant throughout a habitat patch. The edge of a habitat patch is always adjacent to a structurally different habitat or different land use, and as a result it is often vulnerable to 'edge effects'. These can include things like increased light penetration and higher wind speeds as well as greater impacts from what's happening in the adjacent land area. For example, the edge area may be affected by drift from chemicals being sprayed in a neighbouring agricultural area or by unsuitable species spreading in from the adjacent land use (Scottish Natural Heritage, 2010).

Fragmentation

Fragmentation is the breaking down of habitat patches into smaller units of habitat. It is accompanied by changes in quality and quantity of the remaining habitat patches. These changes include an increase in edge effects, reduction in size of habitat and changes in species composition (Treweek, 1999).

'*As habitats become increasingly fragmented, the remaining habitat patches can become too small to support some species which need a large area to survive. So although there may be some suitable habitat left, it may not be of sufficient size to support all the species that are characteristic of that habitat type. For example, red squirrels are thought to need at least 6 hectares of suitable habitat in order to survive and reproduce successfully*.' Scottish Natural Heritage, 2010

As habitat fragmentation takes place, the remaining habitat patches get smaller and the relative amount of habitat edge in each patch increases. That means that a greater proportion of the habitat area is influenced by 'edge effects' decreasing the quality of the habitat patch (Scottish Natural Heritage, 2010).

Some species respond well to those changing conditions and they can be considered as 'edge species', whereas other species respond badly to a relative increase in habitat edge. These 'interior species' need to be further away from edge effects and often need a large habitat patch in order to survive. For example, wild clematis (*Clematis vitalba*) is usually found on the edge of woodland or in narrow hedges, so it could be described as an edge species. In contrast bluebells (*Hyacinthoides non-scripta*) are more frequent in the interior of a woodland and are adversely affected by edge effects (Scottish Natural Heritage, 2010).

Fragmentation into smaller areas can lead to extinction of predators, larger species and habitat specialists as well effecting pollination in flora – for example bluebells produce less seed in smaller areas (Scottish Natural Heritage, 2010). The reduced habitat area would be less able to support a size of population that existed prior to the land use change and may result in inbreeding and eventual local extinction. Many studies have shown that small populations are more likely to suffer extinction through a number of different mechanisms. This effect increases with isolation from patches of similar habitat (Treweek, 1999; Kuttunen et al, 2007).

Species Dispersal

Dispersal is the movement of individuals of a species between habitat patches to either join an existing breeding population or colonise an area to establish a new breeding population.

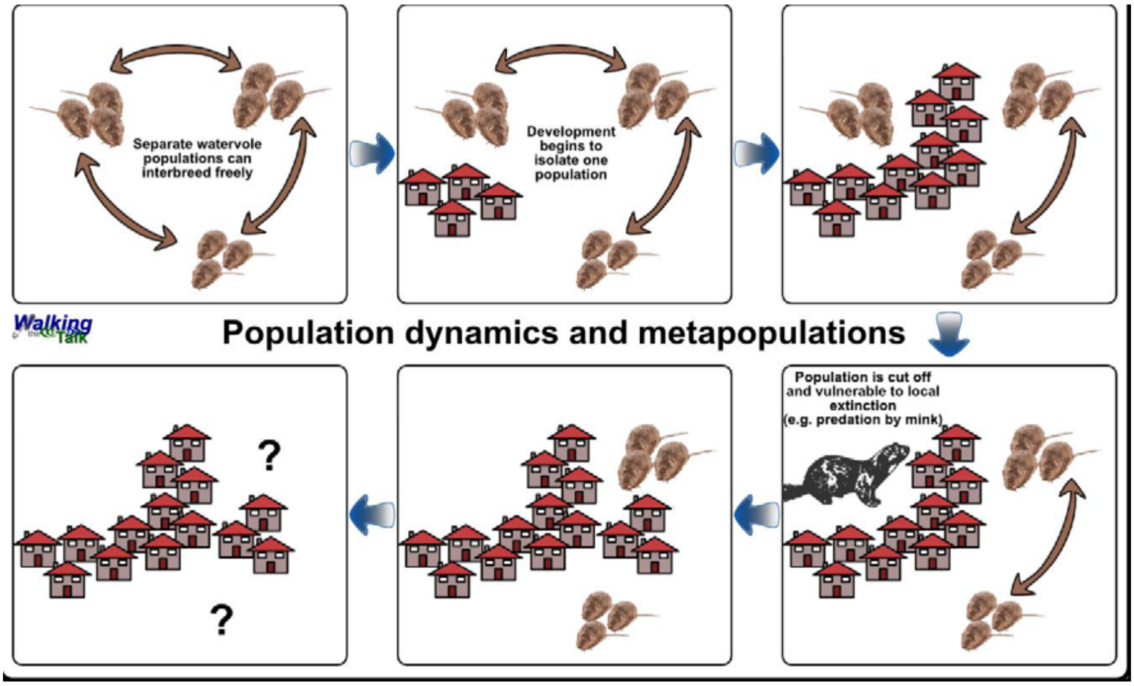
The ability of a species to disperse depends on how the species moves or in the case of plants how well it is able to use factors such as wind or animals to transport their seeds. Many species will have specially evolved means of dispersal which differ behaviourally or mechanically from any other movements the species will make. Species differ in how far they are able to disperse and this will affect how sensitive a species is to habitat fragmentation. Species which have low dispersal abilities are likely to be more affected by fragmentation (Scottish Natural Heritage, 2010).

The long-term survival of species is strongly dependent on the movement of individuals between different habitat patches. This process helps ensure genetic exchange between different populations and secures the capacity of a species and its individual populations to adapt to changing environmental conditions (Kuttunen et al, 2007). In a fragmented landscape where small patches of habitat can be isolated within predominantly urban or agricultural land uses the dispersal ability of some species may not be sufficient to maintain adequate genetic exchange between populations. Research has shown that habitat size and wildlife corridors can aid dispersal and are of vital importance to nature conservation, and to thriving and diverse wildlife (Dufek, 2001; Evink, 2002).

Some populations exist as a metapopulation. This is a set of populations within a larger area linked by the frequent migration of individuals from one population to another (Kuttunen et al, 2007). This means that if one population is reduced or becomes locally extinct, the vacated habitat patch can be recolonised by individuals from other populations within the wider metapopulation. For example, water voles (*Arvicola fluvius*) are thought to function as a metapopulation with individuals moving between populations in different parts of a river catchment. Metapopulations are dependent on individuals being able to move from one population to another which becomes difficult and often impossible in a fragmented landscape. See Figure 1 below (Scottish Natural Heritage, 2010).

If the area between populations becomes too hostile or difficult to cross the different populations will no longer be connected making the individual populations more vulnerable. For example, Figure 1 demonstrates how some populations of water vole in Scotland have suffered local extinctions because of predation by American mink. Where habitat fragmentation has also occurred, the water voles are unable to move through the landscape to recolonise areas once the threat from the mink has been removed (Scottish Natural Heritage, 2010).

Figure 1: Example of Fragmentation of a Metapopulation



Scattered Resources

One habitat patch may not have all the resources a species needs to survive throughout the year or from day to day (Owen-Smith *et al*, 2010). This could be due to the size of the habitat patch or because of particular features of that habitat patch. If the habitat matrix around smaller habitat patches is easier to move through, those smaller habitat patches can support species more easily than if they were completely isolated.

Connectivity

Connectivity refers to the degree to which the landscape facilitates movement between different habitat patches (Kuttunen et al, 2007).

There are two types of connectivity. These are:

- Structural Connectivity
- Functional Connectivity

Structural Connectivity

Structural connectivity refers to physical connections in the landscape between habitat patches. Often structural connections in the landscape are referred to as corridors but these connections do not necessarily have to be linear features, they can be discrete patches of habitat.

Functional Connectivity

Functional connectivity refers to how much the landscape helps or hinders the movement of species and often relates to the vegetation structure or the intensity of management. Functional connectivity is species specific as it depends on the mobility of the species and the habitat types present in the landscape. For example, a grassland species may find woodland physically difficult to move through or a woodland species would be unlikely to cross an intensively managed silage field (Eyecott *et al*, 2011).

Climate Change

Due to changing climate the range and abundance of many species will change, a process that has already been documented for many species. Research studies have shown that climate induced changes include:

- Changes in the timings of seasons, which are getting earlier by 2.3 days per decade. This may lead to loss of synchrony between species, such as the availability of a food source during a species breeding season
- Changes in species distribution and abundance within their existing habitats (including arrival of non-native species and potentially a loss of species for which suitable climate conditions disappear)
- Changes in community composition, such that new combinations of species may occupy habitats
- Changes in ecosystem function, such as changes to water table levels, higher vegetation growth rates or increased rates of decomposition in bogs
- Loss of physical space due to sea level rise and increased storminess.[7]

The UK Biodiversity Partnership has suggested that '… *ecological networks should be established and strengthened by programmes of habitat restoration and creation to improve opportunities for dispersal across landscapes and between regions in response to climate change*'. It is considered that in most cases, improving the quality, size and connections of remaining patches of semi-natural habitat through ecological networks at a local, as opposed to regional level should be sufficient to buffer the effects of climate change (Hopkins et al, 2007).

[7] http://www.parliament.uk/documents/post/postpn300.pdf

4. Ecological Networks

Introduction

Somerset's Ecological Network is being developed in addition to statutorily designated sites, such as SSSI and SAC, and NGO nature conservation sites and includes undesignated species-rich habitats in addition to the priority habitats that these sites are designated for. The ecological network complements the existing process of planning for protected and priority sites, species and habitats**.** It does not remove the legal or policy requirements upon developers to survey, assess, plan and manage potential impacts to wildlife.

The BEETLE least-cost network model (Watts *et al*, 2010) was used to develop Somerset's Ecological Network. This chapter introduces the terms that are used in relation to this model.

Terms to Describe the Ecological Network

Broad Habitat Types

The County of Somerset contains a number of habitats of principle importance (Section 41, The Natural Environment and Rural Communities Act) which are also known as priority habitats in the UK biodiversity Action Plan. These habitats have been grouped together into five broad habitat types that were then modeled to produce separate ecological networks.

The five broad habitat types that were used to model separate ecological networks in Somerset are:

- Broad-leaved Woodland
- Priority Grasslands (including calcareous, acid and neutral grassland)
- Heathland and Acid Grassland
- Fen, Marsh and Swamp
- Rivers and Streams (Represented using an alternative method to the BEETLE least-cost network model)

For a full description of these habitats see Appendix 1

Ecological Network

An ecological network is a group of habitat patches that species can move easily between maintaining ecological function and conserving biodiversity. Through appropriate management, ecological networks can provide a connected collection of refuges for wildlife. These networks are the basic natural infrastructure that will begin to enable biodiversity to recover from recent declines, and help to protect socially and economically important ecosystem goods and services.

Permeability

Permeability and permeability cost refer to the ability of a species to move or disperse through the landscape. If a landscape is highly permeable to a species, the cost of moving through the landscape is low. Permeability of the landscape changes depending on the generic focal species used and the structural similarity of the landscape to the habitat in which that generic focal species prefers to live. For example, a woodland species can pass with ease through woodland habitats because it is adapted to do so but a grassland species would have difficulty as it is used to a more open landscape. Different habitat types (both semi-natural and man-made) affect the ability of species to disperse (Table 1).

In modeling the ecological network for each broad habitat type every field parcel in the landscape has been assigned a permeability cost score which reflects the permeability of that habitat for the generic focal species in question. The permeability cost decreases the distance that the generic focal species is able to move through the landscape.

Table 1: Simplified Permeability Cost Scores

Habitat type	Habitat Permeability for a Generic Woodland Species	Permeability Cost Score
Broadleaved and mixed woodland	Very high	Very low
Woody scrub	Medium	Medium
Arable or roads	Very low	Very high

Coherence

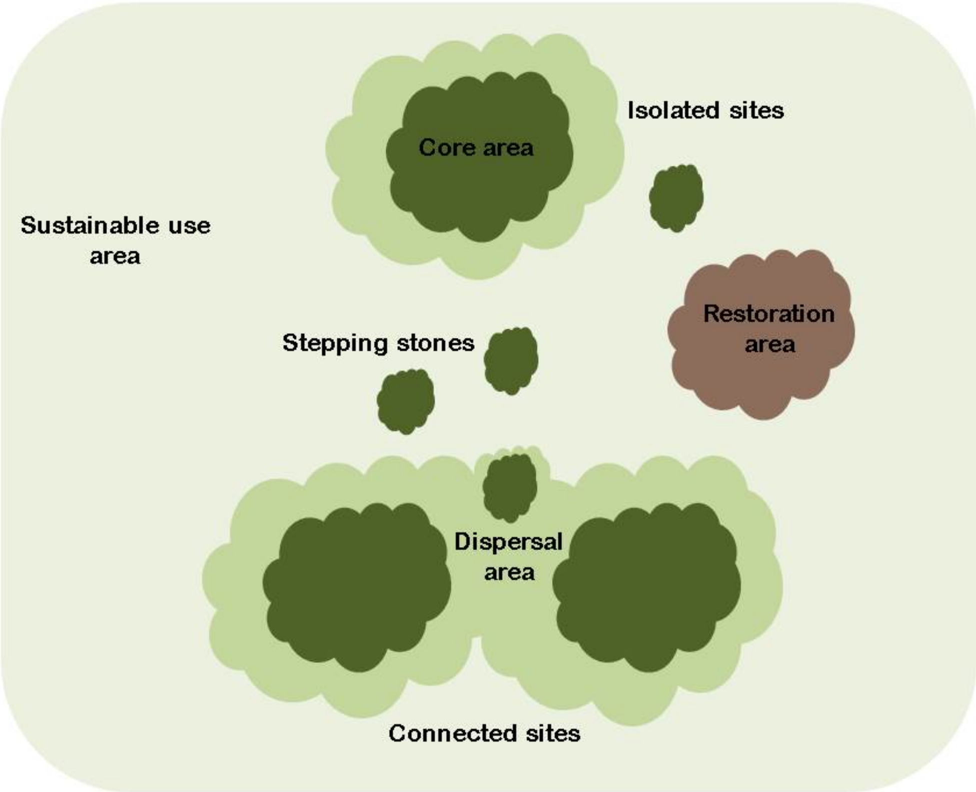
Coherence describes the how well connected the habitat patches within a network and relates to how easily species can move between habitat patches. This is a measure for assessing the current structure of a network.

Resilience

Resilience describes the ability of an ecological network to deal with disturbance events such as loss of core habitat, or negative effects from neighbouring land use. Resilience is a measure for evaluating the ability of the landscape to deal with future risks.

Components of Somerset's Ecological Network

Figure 2: Areas in the Ecological Network



Core Areas

Core Areas are patches of the habitat being modeled that are of meet the "Minimum Viable Area" which means that they are large enough to support a viable population of the generic focal species for that habitat. These areas act as a source of species that can move out into the landscape.

Dispersal Areas

Dispersal areas can be crossed easily by the generic focal species when moving out into the wider landscape. Habitat patches that fall within the same dispersal area are regarded as connected to other habitat patches and form part of the same ecological network. Habitat patches which do not share a dispersal area with another habitat pact are regarded as isolated.

Stepping Stones

Patches of the habitat being modeled that are smaller than the “Minimum Viable Area” are called stepping stones. They may form stretches of habitat that act as corridors or they may be discrete habitat patches that enable species to move across the landscape between core areas. Although small, stepping stones can add to the diversity of the landscape as they may have different groups of species to other habitat patches.

Sustainable Use Areas

This comprises the majority of the landscape and includes all land outside of a dispersal area. Bennett & Mulongoy (2006) define sustainable use areas as ‘*areas within the wider landscape focussed on the sustainable use of natural resources and appropriate economic activities, together with the maintenance of ecosystem services’.* Through sustainable use the permeability of the land surrounding the discrete ecological networks can be improved (Lawton *et al* 2010).

Restoration Areas

Restoration areas are designed to enhance coherence and resilience of ecological networks. For more information on restoration areas see chapter 7 of this document.

5. Modelling Somerset's Ecological Network

Introduction

Modelling the networks using GIS mapping software is a practical, cost efficient way that enables indicative networks to be produced based on the data that is currently available. It is important to note that Somerset's Ecological Network will continue to be updated on a rolling basis as more data becomes available about the species and habitats that make up Somerset's Ecological Network.

This chapter sets out how Somerset's Ecological Network was modeled in ArcGIS 10.2. Two methods have been used to construct the ecological network. These are:

- BEETLE least-cost network model (Watts *et al*, 2010)
- Analysis of Structural Connectivity of Rivers and Streams

BEETLE Least-cost Network Model

Somerset's Ecological Network is represented using a least-cost network model developed by Forest Research (Watts *et al.* 2010), also known as BEETLE (Biological and Environmental Evaluation Tools for Landscape Ecology).

BEETLE is a GIS tool that models ecological networks extending from core areas of habitat. The extent of the network is governed by a set of parameters which are the characteristics of a hypothetical species known as a "generic focal species" (see below).

Landscape permeability in the model, or the degree to which the habitats in the surrounding landscape facilitate or impede movement, is incorporated through the use of a least-cost distance function. This function reduces the maximum dispersal distance of the model species according to the permeability of the surrounding landscape.

The resolution of the output in terms of the minimum patch size that the model will include is set by a "cell size" parameter. The cell size specifies the minimum size of habitat patch that the model can detect. A smaller cell size allows the networks to be modeled in more detail but running the model at this resolution requires more processing power and takes longer. The model has been run for the whole of Somerset and the Exmoor National Park Authority area at a resolution of 10m. The model has been run at a 2m resolution for the Brue Valley and Mendip Hills Living Landscape project areas to allow more detailed analysis of the ecological networks.

Base Map

The BEETLE least-cost network model requires a base map of the area for which ecological networks are to be modeled. The Somerset Habitat Map, produced by Somerset Wildlife Trust (SWT) and Somerset Environmental Records Centre (SERC), was used as the base map for the BEETLE model. This base map is a seamless layer of the whole county, in which every polygon of the Ordnance Survey MasterMap has been assigned a habitat type.

The Somerset Habitat Map is comprised of data from 11 datasets (Table 2) which were prioritised according to the level of detail the dataset provided about the habitat type. Where an area was included in more than one of these datasets the dataset which provided the most detailed habitat information was used. For example data collected by field survey was given greater priority than aerial photo interpretation, which was prioritised over MasterMap data.

The habitats in the Somerset Habitat Map are classified according to the Integrated Habitat System (IHS, © Somerset Environmental Records Centre). IHS represents an integration of existing classifications in use in the UK with particular emphasis on Biodiversity Broad Habitat Types, Biodiversity Priority Habitat Types, Annex 1 of the Habitats Directive and Phase 1. It also includes habitats distinguishing between arable types, improved grassland and neutral grassland, for example.

Datasets in the upper rows of Table 2 provide more detailed habitat information and were used in preference to those lower in the table when assigning habitat types to polygons in the Somerset Habitat Map.

Table 2: Somerset Habitat Map Data

Dataset	Attributes of Data
Brue Valley Living Landscape IHS Data Mendip Hills Living Landscape IHS Data	These datasets were compiled by IHS field survey of Somerset Wildlife Trust's Living Landscape project areas.
Blackdown Hills IHS Data	This dataset was compiled by IHS field survey carried out by SERC for the Forestry Commission.

Dataset	Attributes of Data
RSPB NVC and Phase 1 Data	This data includes 2005 Phase 1 survey data and 1996 NVC survey data for West Sedgemoor.
FWAG Data	Mendip IHS survey carried out by FWAG 2009-2010
SERC Somerset Priority Habitat Layer	Compiled by SERC as part of a national inventory of priority habitats in 2004.
Mendip District Aerial Photo Interpretation Taunton Aerial Photo Interpretation Yeovil Aerial Photo Interpretation	Aerial photo interpretation with classification to IHS codes.
SERC MM IHS data	IHS countywide classification produced by SERC based on the Land Cover Map 2007, originally produced by the Centre for Ecology and Hydrology.
IHS infill data	IHS classification based on MasterMap 2005 that were not included in any of the above data sets. This included roads ad buildings.

Home Habitat

Each of the 4 broad habitat types for which an ecological network has been produced can be divided into a number of more detailed species-rich habitats. These habitats are referred to as "Home Habitats" and support assemblages of key species for the particular habitat being modelled. Table 3 includes all of the habitats which were selected from the Somerset Habitat Map as home habitat for each of the ecological networks with their associated IHS codes.

Table 3: Home Habitat Selection

Habitat Network	IHS Code	IHS Name of Home Habitat
Broadleaved Woodland	WB0	*Broadleaved, mixed, and yew woodland*
	WB1	*Mixed woodland*
	WB2	*Scrub woodland*
	WB3	*Broadleaved woodland*
Broadleaved Woodland	WB31	Upland oakwood
	WB32	Upland mixed ashwoods
	WB32Z	*Other upland mixed ash woods*
	WB321	Tilio-Aceron forests of slopes, screes and ravines (upland)
	WB33	*Beech and yew woodlands*
	WB331	Lowland beech and yew woodland
	WB3313	*Taxus baccata woods of the British Isles*
	WB331Z	*Other lowland beech and yew woodland*
	WB33Z	*Other beech and yew woodlands*
	WB34	Wet woodland
	WB341	*Alluvial forests with Alnus glutinosa and Fraxinus excelsior*
	WB342	*Bog woodland*
	WB34Z	*Other wet woodland*
	WB36	Lowland mixed deciduous woodland
	WB363	*Lowland Tileo-acerion forests of slopes, screes and ravines (lowland)*
	WB36Z	Other lowland mixed deciduous woodland
	WB3Z	*Other broadleaved woodland*
Priority Grassland	GA0	*Acid grassland*
	GA1	Lowland dry acid grassland
	GA12	*Lowland dry acid grassland with calcareous indicators*

Habitat Network	IHS Code	IHS Name of Home Habitat
Priority Grassland	GA13	*Species-rich lowland acid grassland (meeting FEP handbook definition)*
	GA14	*Fairly species-poor lowland acid grassland*
	GAZ	*Upland acid grassland*
	GC0	*Calcareous grassland*
	GC1	Lowland calcareous grassland
	GC11	*Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-brometalia) (Important orchid sites)*
	GC13	*Lowland calcareous grassland with acidic indicators*
	GC14	*Heathy lowland calcareous grassland*
	GC1Z	*Other lowland calcareous grassland*
	GC2	*Upland calcareous grassland*
	GN1	Lowland meadows
	GN11	*Lowland hay meadows (Alopecurus pratensis, Sanguissorba officinalis)*
	GN121	*Somerset lowland meadows with calcareous indicators*
	GN1211	*Mendip lowland meadows with calcareous indicators*
	GN122	*Somerset Levels with acid indicators*
	GN1221	*Mendip Lowland Meadows with acid indicators*
	GN123	*Somerset species-rich lowland meadow*
	GN1231	*Mendip species-rich lowland meadow*
	GN124	*Mendip less species-rich lowland meadow*
	GN1Z	*Other Lowland Meadows*
	GN31	*Mendip neutral grassland “species-rich”*
	GN311	*Mendip neutral grassland with calcareous indicators “species-rich”*
	GN312	*Mendip neutral grassland without calcareous indicators “species-rich”*

Habitat Network	IHS Code	IHS Name of Home Habitat
Priority Grassland	GN31Z	*Mendip Other species-rich neutral grassland*
	GN33	*Brue wet neutral grassland*
	GN331	*Brue wet neutral grassland “species-rich”*
	GN341	*Brue dry neutral grassland “species-poor”*
Heathland and Acid Grassland	EM4	Purple moor grass and rush pasture
	EM41	*Molinia meadows on calcareous, peaty or clayey-silt-laden soils*
	EM421	*Species-rich rush pasture*
	EM422	*Non-annex 1 Molinia meadows*
	EM4Z	*Other purple moor grass and rush pastures*
	GA0	*Acid grassland*
	GA1	Lowland dry acid grassland
	GA12	*Lowland dry acid grassland with calcareous indicators*
	GA13	*Species rich lowland acid grassland*
	GA14	*Fairly species poor lowland acid grassland*
	GAZ	*Upland acid grassland*
	HE0	*Dwarf shrub heath*
	HE1	*European dry heaths*
	HE1Z	*European dry heaths without calcareous indicators*
	HE11	*Limestone heathland*
	HE2	Wet heaths
	HE2Z	*Other wet heaths*
	HE3	Lichen-bryophyte heaths
	HEZ	*Other dwarf shrub heath*
Fen, Marsh and Swamp	EM0	*Fen, marsh and swamp*
	EM1	*Swamp*
	EM11	Reedbeds

Habitat Network	IHS Code	IHS Name of Home Habitat
	EM1Z	*Other swamp vegetation*
	EM2	*Marginal inundation vegetation*
	EM21	*Marginal vegetation*
	EM3	*Fens*
	EM3Z	*Other fens, transition mires, springs and flushes*
	EM311	*Calcareous fens with cladium mariscus and species of the Carex davallianae*
	EM312	*Springs*
	EM313	*Alkaline fens*
	EM31Z	*Other lowland fens*
	EM4	Purple moor grass and rush pasture
Fen, Marsh and Swamp	EM41	*Molina meadows on calcareous, Peaty or clayey-silt-laden soils*
	EM421	*Species-rich rush pasture*
	EM422	*Non-Annex 1 Molinia meadows*
	EM4Z	*Other purple moor grass rush pasture*
	EO0	*Bog*
	EO1	Blanket bog
	EO21	*Degraded raised bogs still capable of natural regeneration*
	EOZ	*Other bogs*
	GN331	*Levels wet neutral grassland "species-rich"*
	HE2	*Wet heaths*
	HE2Z	*Other wet heaths*

Habitats in italics are not Biodiversity Action Plan Priority/Section 41 habitats but have a crucial role in ecological networks.

Generic Focal Species

Representative species known as a generic focal species were developed for each of the four habitat networks being modeled. For each generic focal species the following parameters which represented the habitat requirements of the species had to be specified:

- A minimum viable area (hectares)
- A maximum dispersal distance (metres)

The habitat requirements for the generic focal species (Table 4) are used as the model parameters and determine the structure of the ecological network. Core areas are patches of home habitat that meet the minimum viable area requirement. Patches of home habitat that do not meet this minimum size are represented as stepping stones in the ecological network. The dispersal area which originates from core areas is a function of maximum dispersal distance and the permeability of the landscape.

The parameters for the generic focal species were based on the habitat requirements of 143 species found in Somerset. Most of the species chosen were Somerset BAP species. Those that were not BAP species were considered to be habitat specialists which rely on a particular broad habitat type for feeding or breeding. The method for calculating the characteristics of the generic focal species is included in Appendix 2 and a full list of the data collected is included in Appendix 3 -7.

The data available for dispersal distance and patch size was limited and so professional judgement was required to ensure the parameters which emerged from the data were ecologically valid. The following criteria were used to determine this:

- The parameters chosen should be close to the median, which is the measure of central tendency that is least sensitive to extreme values and best used for data that is not normally distributed.
- The parameters chosen should not represent the species most sensitive to habitat fragmentation. This will avoid producing a restricted ecological network that will not be useful in terms of highlighting restoration areas or key connecting areas in the landscape.
- The dataset used to determine the parameters should include data from a range of species, without one group of species group being overrepresented.
- The minimum viable area for each habitat should represent the typical size of patches of that habitat patches present in Somerset.

Table 4: Summary of Generic Focal Species Metrics

Network	Minimum Viable Area (ha)	Maximum Dispersal Distance (m)
Broadleaved Woodland	8	750
Priority Grasslands	3	500
Heathland and Acid Grassland	3	600
Fen, Marsh & Swamp	2	400

Aggregated Home Habitats

Patches of home habitat that were less than 5m apart, not separated by a road were aggregated and treated as one patch when calculating their size. This allowed large sites divided by a network of footpaths into patches that would not be large enough to meet the minimum viable area individually to be included as core areas. This better represented the importance of sites in the landscape and also takes into account how neighboring sites may function as metapopulations.

Landscape Permeability

In Somerset's Ecological Network permeability cost values were based on consultations with experts using a method known as the Delphi process, organised and facilitated by Eycott *et al* (2011), which determined landscape permeability for three different broad habitat types (broadleaved mixed and yew woodland; neutral grassland; and fen, marsh and swamp).

The permeability costs were reviewed by Somerset Wildlife Trust and Somerset County Council and amended, where appropriate, to suit Somerset habitats (Table 5a). This included the addition of permeability cost scores for the heathland and acid grassland network which was not included in the Delphi process by Eyecott *et al* (2011). Permeability scores also had to be amended for other habitat types as the field surveys carried out in Somerset gathered more refined habitat information than the broad habitat types used by Eycott *et al* (2011).

Permeability scores were allocated according to the IHS main habitat code and also to IHS management codes where this was thought to influence habitat permeability (Table 5b).

Table 5a: Summary of Main Habitat Permeability Cost Scores

A permeability cost score of 0 indicates home habitat for the ecological network.

Habitat	Somerset Habitat Map IHS Codes	Permeability Cost Scores			
		Broad-leaved Woodland	Priority Grassland	Heathland and Acid Grassland	Fen, Marsh and Swamp
Broadleaved and Yew Woodland	WB0, WB1, WB2, WB3, WB31, WB32, WB321, WB32Z, WB36, WB36Z, WB3Z	0	10	10	10
	WB33, WB331, WB3313, WB331Z, WB33Z, WB363	0	10	10	15
	WB34, WB342 , WB34Z	0	20	10	1
	WB341	0	20	10	2
Coniferous Woodland	WC1Z, WC0, WCZ	3	20	10	20
Scrub	SP0	1	2.18	2.18	2.18
Acid Grassland	GA0, GA1, GA12, GA13, GA14, GAZ	4.44	0	0	4
Calcareous Grassland	GC0, GC1, GC11, GC13, GC14, GC1Z, GC2	4.44	0	1.74	4

Habitat	Somerset Habitat Map IHS Codes	Permeability Cost Scores			
		Broad-leaved Woodland	Priority Grassland	Heathland and Acid Grassland	Fen, Marsh and Swamp
Neutral Grassland	GN1, GN11, GN121, GN122, GN123, GN1232, GN124, GN311, GN312, GN31Z, GN341	4.44	0	1.74	4
	GN33	4.44	2	4	2
	GN0, GN3, GN32, GN342, GNZ	4.44	2	4.44	4
	GN331	4.44	0	1.74	0
	GN332	4.44	2	4.44	2
	GN333	4.44	2	4.44	1
Unimproved Grassland	GU0	7	4.44	4.44	7
Bracken	BR0, BR1, BRZ	1.82	4.44	4.44	7.5
Heathland	HE2, HE2Z	2.22	4.44	0	0
	HE0, HE1, HE11, HE1Z, HE3, HEZ	2.22	4.44	0	3
Bare Ground	BV0	20	10	10	10
Bog	EO0, EO1, EO21, E02Z, EOZ	2.5	20	1	0

Habitat	Somerset Habitat Map IHS Codes	Permeability Cost Scores			
		Broad-leaved Woodland	Priority Grassland	Heathland and Acid Grassland	Fen, Marsh and Swamp
Fen, Marsh and Swamp	EM2, EM21, EM3, EM31, EM311, EM312, EM313, EM31Z, EM3Z	2.5	10	10	0
	EM0, EM1, EM11, EM1Z	2.5	20	10	0
	EM4, EM422, EM4Z	4.44	4.44	0	0
Fen, Marsh and Swamp	EM41, EM421	4.44	1.74	0	0
Rivers and Streams	AR0, AR1, AR1Z, ARZ	10	20	20	2
Standing Open Waters and Canals	AS0, AS1, AS1Z, AS3 AS3Z, AS4, AS4Z, ASZ	10	20	20	1
Inland Rock	RE0, RE1, RE11, RE112, RE14, RE141, RE15, RE1Z	5.45	10	10	40
	RE2, RE21, RE22, RE24, RE2Z	10.91	40	40	40
	RE23	10.91	50	50	50
Maritime Rocks and Sediments	SR1	50	50	50	50
	LR0, LR2, LR3, LS0, LS4, SR0, SS1, SS3	50	50	50	50
	LS3	50	15	50	15

Habitat	Somerset Habitat Map IHS Codes	Permeability Cost Scores			
		Broad-leaved Woodland	Priority Grassland	Heathland and Acid Grassland	Fen, Marsh and Swamp
Boundary Linear Features	LF1, LF11, LF11Z, LF12, LF1Z, LF2, LF21, LF24, LF25, LF26,	2.18	2.18	2.18	2.18
Boundary Linear Features	LF0	2.18	5.71	5.71	10
	LF111	1	2.18	2.18	2.18
Arable and Horticulture	CR0, CR1, CR2, CR3, CR31, CR33, CR34, CR35, CR3Z, CR4, CR5, CR6, CR61, CR6Z, CR7, CRZ	10	20	20	20
	GI0, GP0	10	6.67	6.67	10
Transport Corridors	LF272, LF273	2.18	2.18	2.18	2.18
	LF27, LF271	10.91	40	40	40
Urban	UR0	5	13.33	30	30
Unknown Terrestrial Vegetation	OV0, OVZ	6.67	6.67	6.67	6.67
	OV1	4.44	20	6.67	2
	OV2	1.82	4.44	4.44	7.5
	OV3	2	6.67	6.67	10

Table 5b: Summary of Management Code Permeability Scores

Somerset IHS Management Code	Somerset IHS Main Habitat Code	Permeability Cost Score (if different to that of IHS main habitat)			
		Broad-leaved Woodland	Priority Grassland	Heathland and Acid Grassland	Fen, Marsh and Swamp
Wood Pasture and Parkland (WM5)	All WB and WC codes		2	4.44	
	All GA, GC and GN codes. GU0	2			
	GI0, GP0	4			
Currently Managed Wood Pasture/Parkland (WM51)	All WB codes		2	4.44	
Relic Wood Pasture/Parkland (WM52)	All WB codes		2	4.44	
Woodland Ride (WG3)	All WB codes		2	4.44	
Silage (GM21)	All CR and GN codes. GI0, GP0, GU0	10	20	20	20
Frequent Mowing (GN23)	All GN, GC and GA codes	10	6.67	6.67	10
Active Peat extraction (EP1)	All EM codes	20	20	20	20
Currently Active Quarry (RM1)	All codes	50	50	50	50

Somerset IHS Management Code	Somerset IHS Main Habitat Code	Permeability Cost Score (if different to that of IHS main habitat)			
		Broad-leaved Woodland	Priority Grassland	Heathland and Acid Grassland	Fen, Marsh and Swamp
Path and Trackway (UL3)	UR0	5	10	10	40
Wildlife Gardens (UA321)	UR0	2	2	4	2
Allotments (UA33)	UR0	2	2	4	4
Churchyards and Cemeteries (UA41)	UR0	4.44	2	4.44	4
Unintensively Managed Orchards (CL3)	All GN and GC codes	2			
	All WB codes		2	4.44	
	GI0, GP0	4	4	4	7
	GU0	2	2	4	4
Other Unintensively Managed Orchards (CL3Z)	All GN and GC codes	2			
	GI0, GP0	4	4	4	7
	GU0	2	2	4	4
	All WB codes		2	4.44	
Traditional Orchards (CL31)	All GN and GC codes	2			
	GI0, GP0	4	4	4	7
	GU0	2	2	4	4

Somerset IHS Management Code	Somerset IHS Main Habitat Code	Permeability Cost Score (if different to that of IHS main habitat)			
		Broad-leaved Woodland	Priority Grassland	Heathland and Acid Grassland	Fen, Marsh and Swamp
Traditional Orchards (CL31)	All WB codes		2	4.44	
Defunct Orchards	All GN and GC codes	2			
	GI0, GP0	4	4	4	7
	GU0	2	2	4	4
	All WB codes		2	4.44	

Rivers and Streams Ecological Network

The Rivers and Streams Ecological Network was not modeled using the BEETLE least-cost network tool as BEETLE is best used to demonstrate functional connectivity rather than the structural connectivity that operates in a network of rivers and streams.

IHS survey classification is not as detailed for riparian habitats as it is for terrestrial habitats and so a species based approach was used to indicate habitat quality. Core habitats in the river network were selected from OS MasterMap polygons of watercourses that are managed by the Environment Agency based on the location of breeding records of section 41 and European Protected Species and the size of territory typically held or recommended area required for that species (Appendix 7).An 8 metre buffer of the watercourse is included as part of the core area. This is to allow for fringing bankside habitat which forms an important element in the functioning of a watercourse. It is also the specified distance for designating watercourses in the Local Wildlife Sites Guidance for Somerset (Biron, 2010)

6. Outputs from the BEETLE Model

Figure 6: Map of Somerset's Ecological Network

This map represents the components of the ecological network that have been mapped to date (January 2016).

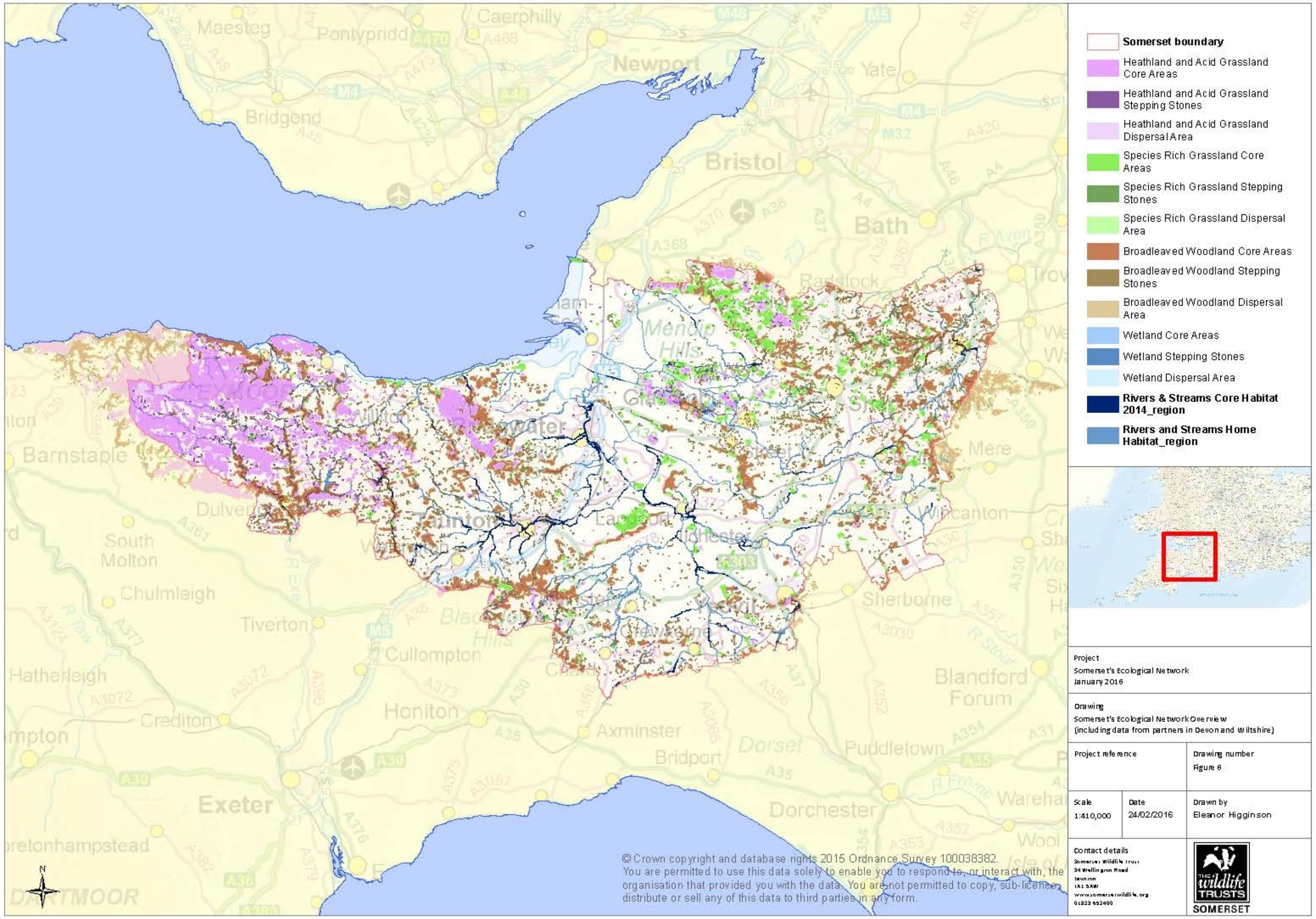
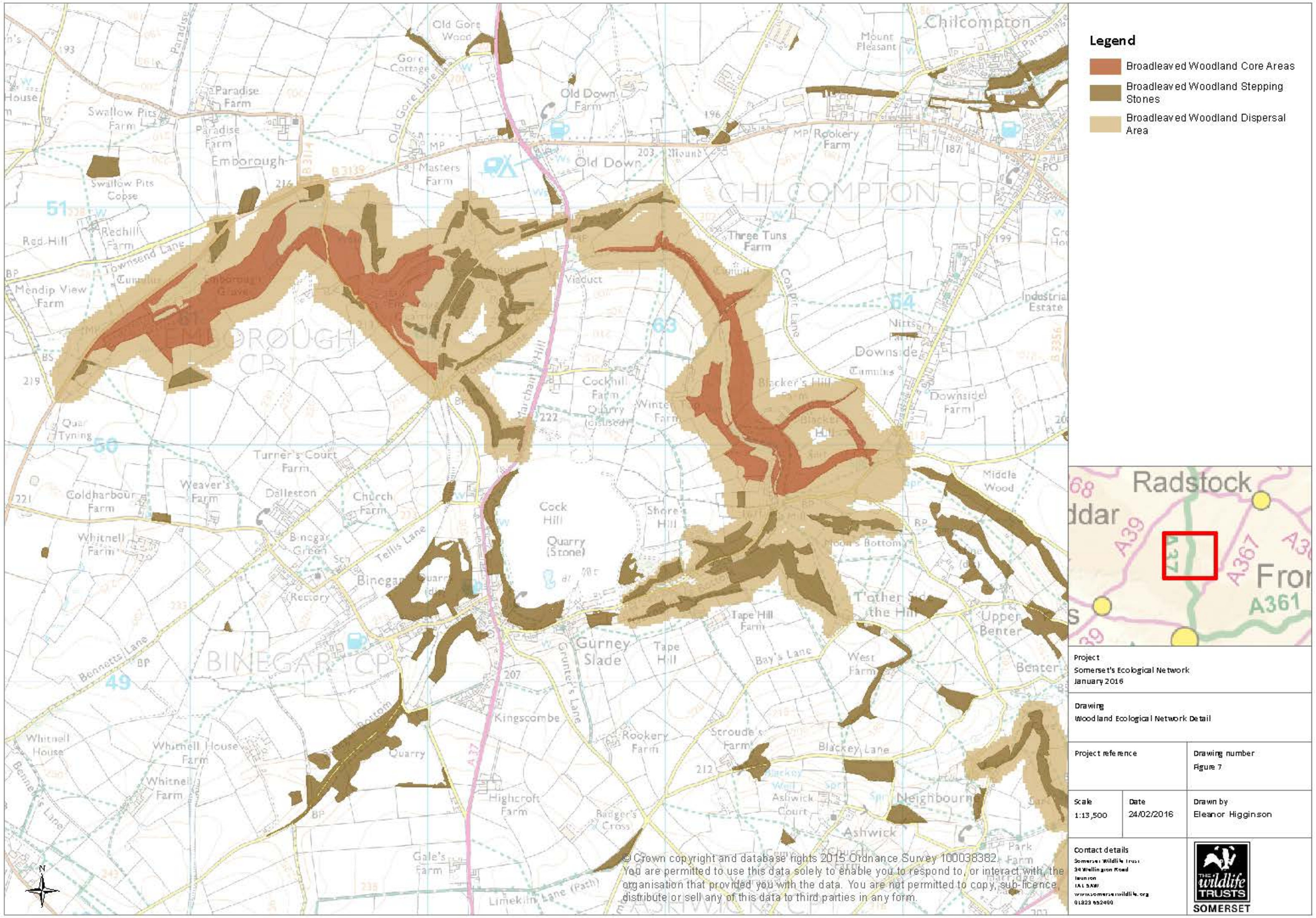


Figure 7: Detail of Woodland Ecological Networks

This figure shows the way in which components of the ecological network can be mapped.



7. Restoration of Ecological Networks

Introduction

A well-functioning ecological network must be both coherent and resilient. This means that the habitat patches that make up the network should be well connected and should be able to withstand the possible negative effects of neighboring land use.

Somerset's Ecological Network represents remnants of what were once more extensive habitats and is in need of restoration to enhance coherence and resilience. The National Planning Policy Framework promotes the identification of areas for habitat restoration or creation by local partnerships (Department for Communities and Local Government, 2011). This is likely to be included in the role of and promoted by the Local Nature Partnership. The Somerset LNP is looking *to '…develop innovative ways of engaging new sectors in work to benefit nature and ecological networks.'* (Somerset Local Nature Partnership, 2014).

Evaluating Ecological Networks

In 2015 Somerset Wildlife Trust commissioned Forest Research to devise a method for evaluating the ecological networks mapped using the BEETLE least-cost network model. Forest Research put together a toolbox that could be run in ArcGIS known as the CORE (**Co**herence and **Re**silience) habitat tool which follows the Lawton principles of bigger, better, more and joined (Lawton *et al*, 2010) to evaluate connectivity in the landscape at both the habitat patch and network scales. The toolbox allocates a score to each habitat patch or network according to the metrics in Table 6. This allows networks and habitats in a defined area to be ranked for coherence and resilience, showing which areas are the most vulnerable and which areas have strong ecological networks.

Full details of the development and use of the CORE toolbox can be found in Moseley *et al* (2015). The CORE toolbox requires the BEETLE model to be run at a 2m resolution which, due to the computer processing requirements, is currently not possible to do at a county scale. The evaluation must be carried out on smaller, discrete areas and so Somerset Wildlife Trust will use the toolbox first in the living landscape areas as these areas are well defined and likely to be where restoration work is focused. To date, this has been completed for the Brue Valley, Mendip Hills and Selwood Living Landscape project areas.

Table 6: CORE Toolbox Ecological Network Evaluation Metrics

CORE Metric	Description and Justification	Bigger/ Better	More	Joined
Network Coherence				
Network area	The area (ha) of each network. A larger network would indicate a more coherent network.			
Proportion of core habitat per network	The percentage of each network made up by core habitat. This metric considers the relationship between the amount of habitat and network size/landscape permeability. This metric can distinguish between networks that have the same area of core habitat but are different sizes because of the permeability of the surrounding landscape.			
Sum of interconnectivity of core habitat	The sum of interconnectivity for each habitat patch within a network (See below). Networks containing habitat with high interconnectivity can be considered to have high coherence.			
Sum of intra-connectivity per network	The area (ha) of each habitat patch within a network squared and summed per network. This measure replaces simple metrics stating the number and size of habitat patches per network and represents a more meaningful relationship between the two. In this case a network with fewer, larger habitat patches would be considered more coherent than one with more, smaller patches.			
Change in interconnectivity with stepping stones	This metric shows the added coherence that stepping stones generate and demonstrates their value more than counting the number of stepping stones in a network.			

CORE Metric	Description and Justification	Bigger/ Better	More	Joined
Habitat Coherence				
Patch location score	Each habitat patch was assigned a score according to its location. Core habitat was assigned the highest score; habitat within the initial network at the recommended dispersal distance was given the next best score. The networks were then run at increasing dispersal distances until 90% of all habitat patches were included in a network. Habitat patches were given a decreasing score according to the network they were included in. Habitat not included in any network was given the lowest score of 1.			
Interconnectivity	This relates to the number of Habitat patches within a set buffer. A higher number indicates a greater amount of connectivity, so habitat patches with a high score are considered to be more coherent.			
Proportional cover	The amount of habitat surrounding each habitat patch within a dispersal distance scale buffer. Patches with a greater proportion of surrounding habitat are considered to be more coherent.			
Network Resilience				
Average weighted resilience score per network	The combined area weighted resilience score for each habitat patch averaged per network. This represents the overall resilience of the habitat within each network and therefore the overall resilience of that network.			
Habitat Resilience				
Patch size	The area (ha) of each habitat patch. Larger patches can be considered more resilient (Lawton et al, 2010)			
Shape index	The relationship between habitat patch perimeter and area. A score of 1 would represent a circle; scores below 1 represent increasingly complex or convoluted shapes. More compact shapes are considered more resilient (Lawton et al, 2010)			

CORE Metric	Description and Justification	Bigger/ Better	More	Joined
Habitat Resilience				
Naturalness	The proportion of natural land cover around each patch within a dispersal distance scale buffer. Unnatural habitat was defined as urban or intensive agricultural land. Patches with a greater proportion of natural habitat around them are considered to be more resilient.			
Edge naturalness	Similar to the above, this measures the proportion of natural land cover around a patch, but only within a 20m buffer, so as to take account of edge effects. Negative edge effects are considered to be greatest if there is a higher proportion of unnatural land cover.			
Proportion designated	The amount of each habitat patch protected by, a designation. The designations considered were: SWT Reserves, SSSIs, SPAs, SACs, LNRs, NNRs, Ramsar and RWLAs. Ramsar and RWLAs were only considered for Fen, Marsh and Swamp habitats as they are related to wetland protection and not relevant for the other broad habitats. Those patches with all or a high proportion of area covered by a designation are considered to be more resilient.			

Restoration Actions

The scores generated by the CORE toolbox allow the weakest aspect of resilience or coherence for each habitat patch and network to be identified. Once this weakness has been identified, targeted restoration work can be recommended that will address this problem and strengthen the functionality of the ecological network.

Opportunities for restoring ecological networks are numerous and restoration can take place within individual networks or between them, often contributing to both coherence and resilience of the ecological network. The examples below are adapted from Oliver *et al* (2012):

Options for restoration areas within individual networks:

- Increasing the size of core areas
- Increasing the quality of the habitat within core areas
- Creating buffers around core areas to soften edge effects. For example, an area of targeted land use next to a core area that does not adversely affect the habitat of the core area
- Increasing structural connectivity between habitat patches
- Improving the permeability of habitats in the dispersal area
- Creating new habitat that can act as stepping stones or corridors

Options for restoration areas between separate networks:

- Ensuring that stepping stones are safeguarded where possible
- Increasing the size or number of stepping stones and corridors between networks with the aim of improving structural connectivity between networks
- Increasing the permeability of the sustainable use areas by favouring land use, landscaping schemes and habitat creation which complement the neighbouring ecological networks with the aim of improving the functional connectivity
- Creating new habitat patches to act as stepping stones or core areas

Selecting Restoration Areas

The CORE toolbox will first be used to evaluate ecological networks for coherence and resilience in areas of Somerset where restoration of the ecological networks is most achievable through existing projects or links with land managers. Networks that are ranked as having poor resilience or coherence are likely to be targeted for restoration but a set of other criteria will also be considered to evaluate the potential benefits of restoring an area and to prioritise where restoration work should take place. These criteria are based on factors which are known to maintain the function of ecological networks and strengthen resilience of networks when faced with disturbance events and future changes in climate. In addition to the rank assigned to networks for resilience or coherence the additional criteria for the selection of restoration areas are:

- Areas where there is the opportunity to change land use i.e. funding available/partnership working
- Areas where there are populations of key species/habitats
- Areas that include SWT Reserves
- Areas where the dispersal area of more than one network overlap
- Areas with clusters of stepping stones

- Areas that could enhance ecosystem service provision
- Restoration areas will include fields that are part of dispersal areas and land between home habitat patches

The restoration of networks involves working at the habitat patch scale and so once a network is selected for restoration individual measures in the CORE toolbox will be used to determine which habitat patches restoration should be the target of restoration area to have the biggest benefit to the network.

Sustainable Use Areas

Restoration work should not simply be focussed in restoration areas or existing ecological networks. Lawton *et al* (2010) defined all land outside of ecological networks as “Sustainable Use Areas” where opportunities should be taken to enhance connectivity. Using the land outside of ecological networks sustainably will strengthen the ecological networks across Somerset.

Sustainable use can be combined with other land use without conflicting with other objectives. In urban areas sustainable use could be the inclusion of green infrastructure or habitat creation within new developments that compliments the surrounding ecological networks. In rural areas it could include agri-environment scheme options that can be tailored to suit local conditions and promote management of farmland that is environmentally sensitive. An example of this is the work that Somerset Wildlife Trust has been involved in with farmers in the Mendip Hills to establish seed trials that are comparing legume and herb rich grass leys with more traditional species poor temporary grass leys. The seed trials, which followed on from work done by the Centre for Ecology and Hydrology (Woodcock *et al*, 2014), were set in place to demonstrate that intensive grassland farming can provide environmental benefits alongside high quality grass, silage and hay production. As well as buffering core areas of grassland habitat, legume and herb rich swards could increase the permeability of the landscape for many grassland species, effectively enhancing ecological networks without requiring changes in land use.

8. Development of Somerset's Ecological Network

Introduction

Somerset's Ecological Network presented in this document can be regarded as an indication of where ecological networks are most likely exist in the County. The networks should be viewed alongside other datasets to give a comprehensive idea of how species move through the landscape and which habitat patches are likely to be connected. The networks produced will be subject to review and further development as new species and habitat data becomes available. A review of the mapped ecological network will be carried out annually by Somerset Wildlife Trust, Somerset County Council, and Somerset Environmental Records Centre.

Network Validation

Each of the habitat networks mapped using the BEETLE least-cost netrwork model have used a generic focal species that has ecological requirements representative of species typical of that habitat. The parameters set for each generic focal species have been chosen to represent a species with high to moderate sensitivity to habitat fragmentation to produce networks that are demonstrate a degree of fragmentation without appearing too restrictive. The features of Somerset's Ecological Network are reliant on the ecological requirements selected for the generic focal species and so it is important that the assumptions made about the parameters of the model are tested against how real species move through the Somerset landscape.

Somerset Wildlife Trust has begun to survey species within the networks that have been modeled to test the validity of the networks. For example in West Mendip, adders have been surveyed as part of the heathland and acid grassland network, and Dormice will be surveyed as part of the woodland network. Initially these surveys will indicate presence or absence of the species in areas thought to be in the same ecological network. Once the distribution of species is known, there is the scope to carry out genetic analysis that will identify distinct populations or groups of individuals that are operating as meta-populations.

Habitat Survey

A limitation of the current model is that it is constrained in places by the detail of the data that has been used to create the base map. Although much of the Somerset Habitat Map outside of urban areas has been determined through recent IHS field surveys, especially in the Brue Valley and the Mendip Hills, over time more land will have detailed surveys carried out. More HIS survey data is being gathered in the new Selwood and Taunton Living Landscape areas and these surveys have already identified new areas of home habitat, adding stepping stones and even core areas to Somerset's Ecological Network. Future HIS surveys may also identify changes in habitat type that are the result of new management or land use that are detrimental to the ecological network.

In addition to data collected directly for the purpose of updating the base map and held by the Somerset Environmental Records Centre, there is also data held by other organisations that could be converted into IHS habitat codes and incorporated into Somerset Habitat Map. The RSPB and FWAG South West have already contributed data to the Somerset Habitat Map which has improved the detail of Somerset's Ecological Network.

The Inclusion of Linear Features

The Somerset Habitat Map includes linear features such as hedgerows and dry stone walls in some areas of the county but not all; this is because linear features are not typically included as polygons in MasterMap which was used as the template for the Somerset Habitat Map but were mapped in a small number of habitat surveys. To convert linear features to polygons so that they can be detected by the BEETLE least-cost network model is a complex task and for simplicity hedges and dry stone walls will not be included in the Somerset Habitat Map. They will however be included in a separate GIS layer which can be displayed alongside the ecological networks modeled using the BEETLE least-cost network model. The hedges will be represented according to their contribution to connectivity which will be judged on species composition, management and structure.

Wetland and Coastal Networks

The BEETLE least-cost network model suits terrestrial habitats very well and is simple to use which is why it has been used here. However, when modeling wetland networks there are a number of other factors such as flood events that can influence how species move through the landscape and where species are able to colonise. It may be necessary to use additional modeling techniques or combine BEETLE with complementary data in order to build a more comprehensive picture of wetland ecological networks.

Somerset's coast is rich in wildlife and has a huge range of habitats from the mud flats of the Severn Estuary to the rock pools of Exmoor. The connections between these habitats in Somerset have not yet been modeled but as SWT develop their Living Coast project the ecological networks of coastal habitats will be better represented.

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Appendix 1: Broad Habitat Descriptions

The following descriptions are derived from **http://jncc.defra.gov.uk/page-3526**

Broadleaved Woodland

Broadleaved and mixed woodland is characterised by vegetation dominated by trees that are more than 5m high when mature, which form a distinct, although sometimes open, canopy with a canopy cover of greater than 20%. It includes stands of both native and non-native broadleaved tree species, and of yew *Taxus baccata*, where the percentage cover of these trees in the stand exceeds 20% of the total tree cover. Stands of broadleaved, mixed and yew woodland may be either ancient or recent woodland or either semi-natural arising from natural regeneration of trees, or planted.

Scrub vegetation, where the woody component tends to be mainly shrubs, which are usually less than 5m high, including juniper *Juniperus communis*, and carr (woody vegetation on fens and bog margins), is included in this category if the woody species form a canopy cover of greater than 30% and the patch size of scrub is greater than 0.25ha.

Lowland Meadow (Neutral Grassland)

Lowland meadows are taken to include most forms of unimproved neutral grassland. In terms of National Vegetation Classification plant communities, they primarily embrace each type of *Cynosurus cristatus - Centaurea nigra* grassland, *Alopecurus pratensis - Sanguisorba officinalis* floodplain meadow and *Cynosurus cristatus - Caltha palustris* flood-pasture. The habitat description is not restricted to grasslands cut for hay, but also takes into account unimproved neutral pastures where livestock grazing is the main land use. It covers the major forms of neutral grassland which have a specialist group of scarce and declining plant species. Among flowering plants, these include fritillary *Fritillaria meleagris,* Dyer`s greenweed *Genista tinctoria,* green-winged orchid *Orchis morio,* greater butterfly orchid *Platanthera chlorantha,* pepper saxifrage *Silaum silaus* and wood bitter vetch *Vicia orobus*. Lowland meadows and pastures are important habitats for skylark and a number of other farmland birds, which has experienced a major range contraction across the UK.

Calcareous Grassland

Calcareous grassland is characterised by vegetation dominated by grasses and herbs on shallow, well-drained soils which are rich in bases (principally calcium carbonate) formed by the weathering of chalk and other types of limestone or base-rich rock. Although the base status of such soils is usually high, with a pH of above 6, it may also be more moderate and calcareous grassland communities can occur on soils with a pH as low as 5. It supports a very rich flora including many nationally rare and scarce species. The invertebrate fauna is also diverse and includes scarce species like the adonis blue *Lysandra bellargus*, the silver-spotted skipper *Hesperia comma*, the Duke of Burgundy fritillary *Hamaeris lucina* and the wart-biter cricket *Decticus verrucivorus*.

Acid Grassland

Acid grassland is characterised by vegetation dominated by grasses and herbs on a range of lime-deficient soils which have been derived from acid rocks such as sandstones, acid igneous rocks and on superficial deposits such as sands and gravels. Although the habitat is typically species-poor, a wide range of communities occur in the UK. This habitat type includes a range of types from open communities of very dry sandy soils, which may contain many annual species, through closed pastures on red brown earths, to damp acidic grasslands typically found on gleys and shallow peats. Acid grassland is characterised by a range of plant species such as heath bedstraw *Galium saxatile*, sheep`s-fescue *Festuca ovina*, common bent *Agrostis capillaris*, sheep`s sorrel *Rumex acetosella*, sand sedge *Carex arenaria*, wavy hair-grass *Deschampsia flexuosa*, bristle bent *Agrostis curtisii* and tormentil *Potentilla erecta*, with presence and abundance depending on community type and locality.

Heathland

Lowland heathlands are characterised by vegetation that has a greater than 25% cover of plant species from the heath family (ericoids). In the lowlands the habitat also typically includes dwarf gorse *Ulex minor* or western gorse *U. gallii*. It generally occurs on well-drained, nutrient-poor, acid soils. Heaths do occur on more basic soils but these are more limited in extent and can be recognised by the presence of herbs characteristic of calcareous grassland. Dwarf shrub heath includes both dry and wet heath types.

Fens and Marshes

Fens and marshes are characterised by a variety of vegetation types that are found on groundwater-fed (minerotrophic), peat, peaty soils, or mineral soils. These may be permanently, seasonally or periodically waterlogged. Fens are peatlands which receive water and nutrients from groundwater and surface run-off, as well as from rainfall. Marsh is a general term usually used to imply waterlogged soil; it is used more specifically here to refer to fen meadows and rush-pasture communities on mineral soils and shallow peats. Swamps are characterised by tall emergent vegetation. Reedbeds (i.e. swamps dominated by stands of common reed *Phragmites australis*) are also included in this type.

Rivers and Streams

In their natural state rivers are dynamic systems, continually modifying their form. The mosaic of features found in rivers and streams supports a diverse range of plants and animals. For example, riffles and pools support aquatic species, and exposed sediments such as shingle beds and sand bars are important for a range of invertebrates, notably ground beetles, spiders and craneflies. Marginal and bankside vegetation support an array of wild flowers and animals. Rivers and streams often provide a wildlife corridor link between fragmented habitats in intensively farmed areas. The plant and animal assemblages of rivers and streams vary according to their geographical area, underlying geology and water quality. Swiftly-flowing upland, nutrient-poor rivers support a wide range of mosses and liverworts and relatively few species of higher plants. The invertebrate fauna of upland rivers is dominated by stoneflies, mayflies and caddisflies, while fish such as salmon *Salmo salar* and brown trout *Salmo trutta* are often present. In contrast, lowland nutrient-rich systems are dominated by higher plants and coarse fish such as chub *Leuciscus cephalus*, dace *Leuciscus leuciscus* and roach *Rutilus rutilus*.

Comparison of UKBAP habitats and the Somerset's Ecological Network Habitats

The following table gives the habitat descriptions used by the UK BAP and the habitat networks used in mapping Somerset's Ecological Network.

Broad Habitats present in the South West	**Priority Habitat Types present in the South West**	**Somerset's Ecological Network habitat**
Broadleaved, mixed and yew woodland	Lowland mixed woodland Lowland beech and yew woods Lowland wood pasture and parkland Upland oak woodland	Broadleaved Woodland
Neutral grassland	Lowland meadows	Priority Grassland
Calcareous grassland	Lowland calcareous grassland	Priority Grassland
Acid grassland	Lowland dry acid grassland	Priority Grassland

Broad Habitats present in the South West	**Priority Habitat Types present in the South West**	**Somerset's Ecological Network habitat**
		Heathland and Acid grassland
Dwarf shrub heath	Lowland heath Upland heath	Heathland and Acid Grassland
Fen, marsh and swamp	Fens Purple moor grass & rush pasture	Fen, Marsh & Swamp
Bogs	Blanket bog	Fen, Marsh & Swamp
Rivers and streams	Rivers and streams	Rivers and Streams

Appendix 2: Information Informing the Development of Generic Focal Species

The Characteristics of the Generic Focal Species have been primarily derived from the Somerset Priority Species list. Species not on this list which were also included must be considered habitat specialists which rely on a particular habitat for feeding or breeding and must also be recorded in Somerset. The Somerset Priority Species List has been produced as part of the local biodiversity action plan (LBAP) process within Somerset. Its purpose is to identify those species within Somerset which are nationally or internationally important in biodiversity terms, populations that have reduced to levels of serious concern, and/or which would achieve most for biodiversity conservation if targeted for local action. It is to be used as a tool to guide conservation action in the future, one of the aims of the list being to prevent accidental loss, through the development / spatial planning process, of species that are not legally protected, but are of biodiversity importance in Somerset.

Note that the species used in informing the metrics in the BEETLE least-cost model do not necessarily occur in each of the districts of Somerset but have been recorded in Somerset as a geographic area. This enables a consistency of approach with the Somerset-wide ecological network.

A literature search gathered information about the home range size and/or dispersal capabilities of 143 species across the four broad habitat types for which networks were modeled using BEETLE. Some taxa were proportionally over represented in the dataset and so some values were removed from the final calculations. See Appendix 3 – 6 for a full list of data used.

Despite every effort being made to carry out a thorough literature search the data used was limited. It is unlikely that such a small dataset could accurately represent the habitat requirements of species and so criteria were developed to allow judgements of whether the figures that came from the data reflected species' landscape requirements.

Criteria for deciding GFS characteristics

1. The figures chosen should be close to the median, which is the measure of central tendency that is least sensitive to extreme values and best used for data that is not normally distributed.
2. The figures chosen should not represent the species most sensitive to habitat fragmentation to avoid producing a restricted ecological network that will not be useful in terms of highlighting restoration areas or key connecting areas in the landscape.

3. The figures should represent a range of types of species and should not be skewed by extreme values.
4. The size of the MVA should represent the size of habitat patches present in Somerset.

The table below summarises the figures chosen for the characteristics of each of the generic focal species.

Habitat	**Dispersal Distance (m)**	**Minimum Viable Area (ha)**	**Justification**
Broadleaved Mixed Yew Woodland	750	8	Dispersal – Median was 200m however, this figure is strongly influenced by a relatively large number of lichens and fungi (figures from the same paper) in the data set with limited dispersal capabilities. Dispersal method for lichen and fungi is dependent on wind rather than habitat permeability and so they should not be over represented. Inclusion of one example of each of these species in the data set changes the dispersal distance to 750m. This figure is also closer to the dispersal distance for woodland species used in Watts (2010). MVA – the median MVA is 8.4ha, which has been rounded down to 8. This is also close to figures used in Watts (2010) for broadleaved woodland.
Priority Grassland	500	3	Dispersal – With only one example of fungi and one example of lichen the dispersal distance is 250m. The dataset was also skewed by a large proportion of plants (from the same paper) all with the dispersal distance of 150m. The number of these plant records in the dataset was reduced. These two manipulations of the data increased the dispersal distance from 200m, which was felt to be too restrictive and not represent all taxa, to 500m. MVA – The median MVA is 2.5ha which has been rounded up to 3.

Habitat	Dispersal Distance (m)	Minimum Viable Area (ha)	Justification
Heathland and Acid Grassland	600 [500]	3 [20]	Dispersal – The median dispersal distance is 585m which has been rounded up to 600m. MVA – The Median MVA is 2.5 which ahs been rounded up to 3.
Fen, Marsh and Swamp	400 [400]	2 [20]	Dispersal – The median dispersal distance was 360m. This has been rounded up to 400m MVA – The median value is 2.3 which has been rounded down to 2ha

Appendix 3: Woodland Species Data used for Generic Focal Species Development

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Ants, Wasps & Bees (Hymenoptera)	Formicoxenus nitidulus	Shining Guest Ant	Mated queens may fly to other host nests, or may return to their own nest in order to establish a new colony. If the host colony moves its nest, or establishes new nests, the guest ant moves with it. http://www.arkive.org/shining-guest-ant/formicoxenus-nitidulus/#text=Biology	25		
Birds	Phylloscopus sibilatrix	Wood Warbler	Although dependant on topography and song-post fidelity, this generally implicated a distance of over 300 m. Seven birds that had been ringed in the nest, later defended a territory at a distance of 300 metres - 4.6 kilometres from the native territory. Interterritorial territory up to 450 metres. (Herremans, 1993*)*	4600	Wood warbler territories occurred at between 1 to 8 per hectare in Finland. (Tiainen et al, 1983)	N/A - Reliant on woodland patches in a wider network of woodland
Birds	Poecile montanus	Willow Tit	Average breeding dispersal distance 244 metres, Siffczyk et al, 2003; Orell et al. 1999 http://thule.oulu.fi/vaccia/reports/Vaccia_ACT11_deli1_2011.pdf In Britain, Willow Tit is resident and highly sedentary; of 114 ringing recoveries 89 were within 5 kilometres of the original ringing site and only 4 were from distances greater than 20 kilometres. http://www.gmbp.org.uk/site/images/stories/willow%20tit%20bap_09.pdf	5000	Birds have large territories, up to 1200m in length in the Forest of Dean. One observer recorded a territory of over 500m. http://www.ben-macdonald.co.uk/Site/15.willowtits.html.	N/A - Reliant on woodland patches in a wider network of woodland

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Birds	Poecile palustris	Marsh Tit	Farmland with woods and copses. Roams a territory of about 5 to 6 hectares (Holden & Cleeves, 2002. A mean territory size of 4.1 ha was identified Broughton et al, 2006; Broughton et al, 2010)	150	Marsh tit territories were on average when breeding 4 to 5.5 ha (Hinsley et al, 2007) A mean territory size of 4.1 ha was identified in Monks Wood (Broughton et al, 2006) Breeding marsh tits do not occur until a woodland reaches about 25 ha in size (Hinsley et al, 1994) .	25
Birds	Parus Major	Great Tit	Dispersal distance sourced from Nilsson (1989) found in Sutherland et al. (2000)	3300	MVA sourced from Both & Visser (2000) found in Bowman (2003)	1
Birds	Cyanistes caeruleus	Blue Tit	Dispersal distance sourced from Berndt and Sternberg (1968) found in Sutherland et al. (2000)	4700	MVA sourced from Blondel (1985) found in Bowman (2003)	1.6
Birds	Sitta europea	Nuthatch	Dispersal distance sourced from Matthysen et al. (1995)	1679	MVA sourced from Enoksson & Nilsson (1983) found in Bowman (2003)	2.3
Birds	Strix aluco	Tawny Owl	Dispersal distance sourced from Southern (1970) found in Sutherland et al. (2000)	22400	MVA sourced from Schoener (1968) found in Bowman (2003)	36
Birds	Asio otus	Long Eared Owl	Dispersal distance sourced from Newton (2002)	437000	MVA sourcd from Craighead & Craighead (1956) found in Schooner (1968)	55
Birds	Accipter gentilis	Northern Goshawk	Dispersal distance sourced from Marcstrom & Kenward (1981) found in Sutherland et al. (2000)	115000	MVA sourcd from Craighead & Craighead (1956) found in Schooner (1968)	212
Birds	Accipter Nisus	Eurasian Sparrowhawk	Dispersal distance sourced from Marquiss & Newton (1983) found in Sutherland et al. (2000)	108000	MVA sourced from Marquiss & Newton (1981) found in Bowman (2003)	241

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Butterflies & Moths (Lepidoptera)	Agrochola helvola	Flounced Chestnut	It has been demonstrated that the average dispersal distance of a moth is related to its wingspan. The furtherest distance travelled was by a setaceous hebrew character moth at 1170 metres. (Dulieu et al, 2007). The setaceous hebrew character moth has a wingspan of between 35 and 42mm (http://ukmoths.org.uk/show.php?bf=2126) The flounced chestnut has a wingpsan between 30 and 35mm http://ukmoths.org.uk/show.php?bf=2265http://ukmoths.org.uk/show.php?bf=2265.	1000		8
Butterflies & Moths (Lepidoptera)	Cymatophorima diluta	Oak Lutestring	The oak lutestring moth has a wing span of between 33 and 36mm (http://ukmoths.org.uk/show.php?bf=1658) - dispersal distance estimated from Dulieu et al, 2007.	1000		8
Butterflies & Moths (Lepidoptera)	Leptidea sinapis	Wood White	Wood white butterfly adults were found to move very occasionally between sites over a linear distance of 4 kilometres, indicating that dispersal can occur over quite large distances (Asher et al, 2001).	4000	At most woodland sites they occur in discrete colonies though there may be considerable movement between suitable glades and rides (Asher et al, 2001). Minimum size of woodland is Not sourced	
Butterflies & Moths (Lepidoptera)	Limenitis camilla	White Admiral	Can colonise over distances of many kilometres. Asher et al, 2001. 5000m assumed	5000	Discrete colonies in woodland habitat at low density - 2 to 3 adults seen a time mobile (Asher et al, 2001) Minimum size of woodland for discrete viable colony is Not sourced	

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Butterflies & Moths (Lepidoptera)	Minoa murinata	Drab Looper	Area restricted; small flight range (van der Meulenn& Groenendjik, 2005).The drab looper has a wingspan between 14 and 18mm.http://ukmoths.org.uk/show.php?bf=1878 - dispersal distance estimated from Dulieu et al, 2007.	350		
Butterflies & Moths (Lepidoptera)	Salebriopsis albicilla	A micro-moth	It appears that micro moths in woodland patches that are isolated by 250 metres (Fuentes-Montemayor et al, 2012)	200		
Butterflies & Moths (Lepidoptera)	Sciota hostilis	A micro-moth	Fuentes-Montemayor et al, 2012	200		
Butterflies & Moths (Lepidoptera)	Watsonalla binaria	Oak Hook-tip	The oak hook-tip moth has a wing span of between 18 and 30mm (http://ukmoths.org.uk/show.php?bf=1646) - dispersal distance estimated from Dulieu et al, 2007.	1150		
Fungi	Boletus rhodopurpureus	A bolete fungus	Spore dispersal to downwind to distance of about 100m is easily demonstrable (Carlile, M. J., Warkinson, S. C., & Gooday, G. W. 2001. The Fungi. London: Academic Press)	200		
Fungi	Boletus torosus	A bolete fungus	Carlile et al, 2007	200		
Fungi	Cantharellus friesii	A fungus	Carlile et al, 2007	200		
Fungi	Cantharellus melanoxeros	A fungus	Carlile et al, 2007	200		

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Fungi	Chlorencoelia versiformis	A fungus	Carlile et al, 2007	200		
Fungi	Cotylidia pannosa	A polypore fungus	Carlile et al, 2007	200		
Fungi	Hydnellum concrescens	Zoned Tooth	Carlile et al, 2007	200		
Fungi	Hydnellum spongiosipes	Velvet Tooth	Carlile et al, 2007	200		
Fungi	Hygrocybe ceracea	Butter Waxcap	Carlile et al, 2008	200		
Fungi	Phellodon confluens	Fused Tooth	Carlile et al, 2009	200		
Fungi	Phylloporus pelletieri	A bolete fungus	Carlile et al, 2010	200		
Fungi	Piptoporus quercinus	Oak Polypore	Carlile et al, 2011	200		
Hoppers (Homoptera)	Platymetopius undatus	A leafhopper	http://www.jcronin.biology.lsu.edu/biograph/publications/Planthopper%20movement%202003.pdf	100		
Lichens	Bacidia circumspecta	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Lichens	Biatoridium monasteriense	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Lichens	Cetrelia olivetorum	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Lichens	Enterographa sorediata	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Lichens	Lecidea erythrophaea	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Lichens	Lobaria pulmonaria	A lungwort lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Lichens	Megalospora tuberculosa	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Lichens	Parmelina quercina	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Lichens	Rinodina isidioides	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Lichens	Wadeana dendrographa	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Lichens	Wadeana minuta	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Mammals	Muscardinus avellanarius	Hazel Dormouse	A male dormouse may disperse up to 1600 metres from its natal habitat, up to 1700 metres (Bright & Morris, 2008). Maximum distances travelled from the birth place by young born in May-July were 800-1200 m, mean distance (n = 65) being 363 ± 28 m (Juškaitis, 1997) Appear to be able to cross minor roads and grassland with only patchy scrub during dispersal (Garland & Woods, 2005). In Saxony it has been found that dispersing juvenile dormice can cross between 250 and 500 metres of open land between woodland, including across wheat and maize fields (Büchner, 2008)	800	They have been found in habitat patches of little as 1.7 hectares in size along road verges in Somerset (Garland & Woods, 2005) but it is considered that 20 hectares is required for a sustainable population in the long term (Bright et al, 2006). Twenty hectares of woodland indicates that a population of about 60 to 80 dormice is needed for it to be viable. However, note that where woodland is highly fragmented they are found only in large woodland of 50ha or more (Bright & Morris, 2008) indicating a higher minimum viable population than calculated above.	20
Mammals	Myodes glareolus	Bank Vole	Dispersal distance sourced from Dickman & Doncaster (1989) found in Sutherland et al. (2000)	400	Korn, H. (1986). Changes in home range size during growth and maturation of the wood mouse (Apodemus sylvaticus) and the bank vole (Clethrionomys glareolus). Oecologia, 68(4), 623-628.	0.412
Mammals	Meles meles	Badger	Dispersal distance sourced from Newton (2002)	7800	MVA sourced from Gittleman & Harvey (1982)	87

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Mammals	Apodemus sylvaticus	Wood Mouse	Dispersal distance sourced from Dickman & Doncaster (1989) found in Sutherland et al. (2000)	500		
Mammals	Myotis bechsteinii	Bechstein`s Bat	Radio tracking of Bechstein's bats from Bracket's Coppice was carried out in 1998 and 1999 by the Vincent Wildlife Trust in the months between May and August. The maximum range of foraging was 0.98 kilometres from a roost site within the woodland (Schofield & Morris, 2000). Bechstein's bats have a small range of movement around summer roost of about 1 kilometre. The main foraging areas are usually from 500 to1500 metres from the roost. (Boye & Dietz, 2005; Fitzsimmons et al, 2002) However, distance of 250 metres is used in modelling gaps between woodland elements. The distance has been derived from a study of structural connectivity between woodland elements compared to habitat use from radio tracking studies of horseshoe bats (Jones & Billington, 1999; Billington, 2000)	250	Nursery colonies consist of between 10 and 50 and in rare cases up to 80 female bats (Dietz et al, 2009). In Britain maternity colonies vary in size between 20 to 130 adults dispersed into sub groups in different roosts within a small area (<15ha) [Schofield & Greenway, 2008].	15

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Mammals	Myotis brandtii	Brandt's Bat	Maximum foraging distance in England 2.3km. In Germany 1.5km to 10km (Berge & Jones, 2008b) However, distance of 250 metres is used in modelling gaps between woodland elements. The distance has been derived from a study of structural connectivity between woodland elements compared to habitat use from radio tracking studies of horseshoe bats (Jones & Billington, 1999; Billington, 2000)	250	Uses up to 13 hunting grounds of 1 to 4 ha (Dietz et al, 2009) However, the minimum size of a woodland patch is not critical.	N/A
Mammals	Plecotus auritus	Brown Long-eared Bat	Summer foraging grounds lie within a few hundred metres of the roost but can be up to 2.2 kilometres and extend to 3.3 kilometres in the autumn. However, most bats spend most of their time within 500 metres of the roost (Dietz et al, 2009) However, distance of 250 metres is used in modelling gaps between woodland elements. The distance has been derived from a study of structural connectivity between woodland elements compared to habitat use from radio tracking studies of horseshoe bats (Jones & Billington, 1999; Billington, 2000)	250	Brown long-eard bats use feeding areas of about 4 hectares, rarely over 11 hectares, with core hunting grounds smaller than 1 hectare (Dietz et al, 2009) However, the minimum size of a woodland patch is not critical.	N/A

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Mammals	Rhinolophus hipposideros	Lesser Horseshoe Bat	At Hestercombe House individual lesser horseshoe bats were recorded in late July/early August travelling distances of 5 and 6 kilometres to feeding areas (Billington, 2005). Bontadina et al study (2002) a colony of 300 bats had a maximum foraging range of 4.2 kilometres. Gaps as little as 10 metres could prevent movement along a flight line. A distance of 250 metres is used in modelling gaps between woodland elements. The distance has been derived from a study of structural connectivity between woodland elements compared to habitat use from radio tracking studies (Jones & Billington, 1999; Billington, 2000)	250	Individual home ranges of females from maternity colonies are between 12 and 53 hectares in area (Boye & Dietz, 2005). In Bavaria a female lesser horseshoe bat was recorded as using 7 different foraging areas over three nights. The size of foraging area varied between 3.6 and 18.2 hectares (mean 8.4 hectares). (Holzhaider et al, 2002) This would translate as a mean of 58.8 hectares of feeding area being used per bat within the area of the landscape used by the colony. However, the minimum size of a woodland patch is not critical.	N/A

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Molluscs	Ena montana	Mountain Bulin Snail	*Helicigona lapicida* showed a median dispersal was only 1.7 m 5 months after release, but increased to about 6.4 m after 2 years. These results roughly agree with the measured dispersal rates of other species of land snails. http://snailstales.blogspot.co.uk/2006/10/land-snail-dispersal.html. Active dispersal is not as limited as previously thought. In the field, *Xeropicta derbentina* the capture-mark-recapture method recorded a maximum distance covered of 42 m in 6 months within a radius of 38 m from the original release point. (Aubry et al, 2006)	40	Not sourced	?
True Flies (Diptera)	Brachypalpus laphriformis	A hoverfly	Assumed: http://www.sbes.stir.ac.uk/conservation_conference/documents/ERotheray.pdf; http://www.calsurv.org/sites/calsurv.org/files/u3/documents/Category_C.pdf#page=74	3000	Not sourced	?
True Flies (Diptera)	Brachypeza armata	A fungus gnat	http://www.jstor.org/pss/3493495; Assumed based on Midges reached areas over 3 km from the lake, but more than 90% of the midges flew within 500 m of the lake's shoreline (Hirabayashi, 1991)	1000	Not sourced	?
True Flies (Diptera)	Ctenophora flaveolata	Yellow-ringed comb-horn cranefly	Populations are separated by distances of 250 metres (Freeman, 1964)	250	Not sourced	?

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
True Flies (Diptera)	Lipsothrix nervosa	A cranefly	Freeman, 1964	250	Not sourced	?
True Flies (Diptera)	Meligramma guttatum	A hoverfly	Based on Rotheray, E. L. http://www.mallochsociety.org.uk/hamm-2006/	3000	Not sourced	?
True Flies (Diptera)	Myolepta dubia	A hoverfly	Based on Rotheray, E. L. http://www.mallochsociety.org.uk/hamm-2006/	3000	Not sourced	?
True Flies (Diptera)	Neoempheria striata	A fungus gnat	http://www.jstor.org/pss/3493495; Assumed based on Midges reached areas over 3 km from the lake, but more than 90% of the midges flew within 500 m of the lake's shoreline (Hirabayashi, 1991)	1000	Not sourced	?
True Flies (Diptera)	Oxycera leonine	A soldier fly	Soldier flies are week fliers. http://entomology.cornell.edu/cals/entomology/extension/vet/upload/Common_pest_fly_factsheet.pdf	250	Not sourced	?
True Flies (Diptera)	Oxycera terminata	A soldier fly	Soldier flies are week fliers. http://entomology.cornell.edu/cals/entomology/extension/vet/upload/Common_pest_fly_factsheet.pdf	250	Not sourced	?
True Flies (Diptera)	Xylota abiens	A hoverfly	Based on Rotheray, E. L. http://www.mallochsociety.org.uk/hamm-2006/	3000	Not sourced	?
Vascular Plants	Cephalanthera damasonium	White Helleborine	Greene, D. F. & Calogerpoulos, C. 2002.	150	Not sourced	?
Vascular Plants	Epipactis leptochila	Narrow-lipped helleborine	Greene & Calogerpoulos, 2010	150	Not sourced	?

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Vascular Plants	Monotropa hypopitys	Yellow Bird`s-nest	Greene & Calogerpoulos, 2010	150	Not sourced	?
Vascular Plants	Neottia nidus-avis	Bird's-nest Orchid	Greene & Calogerpoulos, 2010; diaspores minute	150	Not sourced	?
Vascular Plants	Platanthera chlorantha	Greater Butterfly-orchid	Greene & Calogerpoulos, 2010; diaspores minute	150	Not sourced	?
Vascular Plants	Sorbus "taxon D"	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?
Vascular Plants	Sorbus admonitor	No parking whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?
Vascular Plants	Sorbus anglica	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestio	?	Not sourced	?
Vascular Plants	Sorbus bristoliensis	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?
Vascular Plants	Sorbus devoniensis	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?
Vascular Plants	Sorbus eminens	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?
Vascular Plants	Sorbus porrigentiformis	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source (MVA)	MVA (ha)
Vascular Plants	Sorbus rupicola	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?
Vascular Plants	Sorbus subcuneata	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?
Vascular Plants	Sorbus vexans	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?
Vascular Plants	Sorbus wilmottiana	A whitebeam	Greene & Calogerpoulos, 2010; dispersed by animals and birds through digestion	?	Not sourced	?

Appendix 4: Species-rich grasslandSpecies used for Generic Focal Species Development

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (Ha)
Ants, Wasps & Bees (Hymenoptera)	Bombus sylvarum	Shrill Carder Bee	Minimum mean foraging distances were calculated as 231 ± 58 metres for *B. sylvarum* (Connop et al, 2010)	250		
Beetles (Coleoptera)	Meloe rugosus	Rugged Oil Beetle	Oil beetle larvae use bees to disperse **http://www.arkive.org/oil-beetle/meloe-proscarabaeus/#habitat**	250		
Birds	Alauda arvensis	Skylark	The breeding dispersal range is recorded as being 0.7 km and for natal dispersal as 5.5km (Wernham et al, 2002).	5500	From 1 pair to 17 pairs per site in Somerset (Somerset Birds, 2003) On average there are 23 pairs in a flock each pair occupying 0.25 to 20 hectares. (Entomological Monitoring Services - British Bird Database 1999 sample)	
Butterflies & Moths (Lepidoptera)	Agonopterix atomella	Greenweed Flat-body Moth	It has been demonstrated that the average dispersal distance of a moth is related to its wingspan. The furtherest distance travelled was by a setaceous hebrew character moth at 1170 metres. The setaceous hebrew character moth has a wingspan of between 35 and 42mm (Dulieu, et al, 2007). Based on this the greenweed flat-body moth (Wingspan c. 20mm http://ukmoths.org.uk/show.php?bf=1740) is likely to have a dispersal range of 500 metres.	500	Not sourced. Probably exists in metapopulations	
Butterflies & Moths (Lepidoptera)	Aricia agestis	Brown Argus	Restricted to isolated fragments of calcareous grassland. Exists in metapopulations. Mark – recapture surveys have shown that the brown argus regularly travels over 100 metres, and can move over 300 metres of improved farmland between adjacent hills (Asher et al, 2001). Wilson & Thomas (2002) found that only 4% of individuals were likely to disperse over 500 metres.	500	The median occupied patch size for a study in North Wales was 0.2 hectares with an interquartile range between 0.04 and 1.21 ha (Wilson et al, 2002) Probably exists in metapopulations	0.2

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (Ha)
Butterflies & Moths (Lepidoptera)	Cupido minimus	Small Blue	Adults rarely move more than 40 m. However, some longer movements have been recorded, including a few of over 1 km between neighbouring sites and vagrants have been recorded in Wiltshire as far as 17 km from known colonies (Fuller 1995) **http://www.butterf**	1000	Tends to live in small colonies. http://www.butterfly-conservation.org/uploads/sb_action_plan.pdf The minimum area in which small blue butterflies have been found is 0.04 hectares. However the larger the area of the host plant the greater the population of small blue were present. (Krauss et al, 2004a) Probably exists in metapopulations	
Butterflies & Moths (Lepidoptera)	Epirrhoe galiata	Galium Carpet	It has been demonstrated that the average dispersal distance of a moth is related to its wingspan. The furtherest distance travelled was by a setaceous hebrew character moth at 1170 metres. The setaceous hebrew character moth has a wingspan of between 35 and 42mm (Dulieu, et al, 2007). Based on this the galium carpet moth (Wingspan 28-32 mm http://ukmoths.org.uk/show.php?bf=1740) is likely to have a dispersal range of 700 metres.	700	Not sourced. Probably exists in metapopulations	
Butterflies & Moths (Lepidoptera)	Erynnis tages	Dingy Skipper	Sedentary: Asher et al, 2001. It is a sedentary species and is unlikely to colonise new areas of habitat unless they are close to existing populations, although observations of natural colonisations suggest that a few individuals can travel several kilometres (Bourne et al., 2000).	200	The dingy skipper is known to occur in small isolated colonies. (Bourne et al., 2000) Most colonies are small and much localised - a typical colony will comprise of between 30-50 adults. The largest known colony, on a stretch of under cliff in Dorset, probably holds about 200-300 adults at peak season. http://www.learnaboutbutterflies.com/Britain%20-%20Erynnis%20tages.htm	
Butterflies & Moths (Lepidoptera)	Euphydryas aurinia	Marsh Fritillary	Movements in a site were recorded by Porter (1981) as on average less than 100 metres. In Finland the recorded maximum dispersal distance for female marsh fritillaries was 510 metres (average 467 metres), whilst for males it is 1.3 kilometres (average 645 metres). However, colonisation has been recorded at distances from known populations of between 5 and 20 kilometres by Warren (1994) [Borsje, 2011]	5000	Marsh fritillaries require 70 hectares of suitable habitat to sustain populations in the long term. They occurred at 20 individuals per 0.92 hectares in Belgium.	70

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (Ha)
Butterflies & Moths (Lepidoptera)	Maculinea arion	Large Blue Butterfly	Re-established adults have some dispersal capability and have been found in new colonies 2 - 3 kilometres away, covering numerous small patches of suitable habitat (Asher et al, 2001).	3000	Large blue butterflies have discrete colonies on small patches (typically 2-5 hectares) from which adults rarely stray (Asher et al, 2001).	5
Butterflies & Moths (Lepidoptera)	Noctua orbona	Lunar Yellow Underwing	The lunar yellow underwing moth has a wing span of between 38 and 45 mm (http://ukmoths.org.uk/show.php?bf=1646) - dispersal distance estimated from Dulieu et al, 2007.	1200	Not sourced Probably exists in metapopulations	
Butterflies & Moths (Lepidoptera)	Polymattus coridon	Chalk-hill Blue	The chalk-hill blue is considered a sedentary to moderately dispersing species with a dispersal range of average of 2 kilometres or between 0.5 and 3 kilometres. (Brückmann et al, 2011).	1085	Population density ranged between 0.04 and 0.32 adults per m². (Brückmann et al, 2011). However a study in Germany found that only 3.2% moved between patches (Schmitt et al, 2006 in Rosin et al, 2011) Probably exists in metapopulations	
Butterflies & Moths (Lepidoptera)	Scotopteryx bipunctaria	Chalk Carpet	The chalk carpet moth has a wing span of between 32 and 38mm (http://ukmoths.org.uk/show.php?bf=1731) - dispersal distance estimated from Dulieu et al, 2007.	800	Not sourced Probably exists in metapopulations	
Fungi	Hygrocybe calciphila	A basidiomycete fungus	Spore dispersal to downwind to distance of about 100m is easily demostratab;le (Carlile, M. J., Warkinson, S. C., & Gooday, G. W. 2001. The Fungi. London: Academic Press)	200	Not sourced. Probably exists in metapopulations	
Fungi	Hygrocybe calyptriformis var. calyptriformis	Pink Waxcap	Carlile et al, 2001; distances assumed	200	Not sourced. Probably exists in metapopulations	
Fungi	Hygrocybe spadicea	Date Waxcap	Spore dispersal to downwind to distance of about 100m is easily demonstrable (Carlile, M. J., Warkinson, S. C., & Gooday, G. W. 2001. The Fungi. London: Academic Press)	200		
Fungi	Hygrocybe virginea var. ochraceopallida	A basidiomycete fungus	Carlile et al, 2001; distances assumed	200		

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (Ha)
Lichens	Fulgensia fulgens	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Liverworts	Cephaloziella calyculata	A liverwort	Liverworts have a characteristic method of spore dispersal. As the liverwort capsule dries, it opens up. Then the helical cell wall thickenings of the elater dry out and the elater changes its shape. As this happens, the elater releases the bound spores which are then dispersed by wind. http://science.jrank.org/pages/3968/Liverwort-Spore-dispersal.html. Wind taken as small seeds = 150 metres ((Greene & Calogeropoulos, 2002)	150		
Mammals	Microtus agrestis	Field Vole	Dispersal distance sourced from Sandell et al. (1990) found in Sutherland et al. (2000)	159		
Mammals	Mustela erminea	Stoat	Dispersal distance sourced from Erlinge (1977) found in Sutherland et al. (2000)	1000	MVA sourced from Alterio (1998)	94
Mammals	Lepus europeaus	Brown Hare	Dispersal distance sourced from Broekhuisen & Maaskamp (1982) found in Sutherland et al. (2000). Lepus europeaus is registered on the BAP 2009.	9000	MVA sourced from Smith et al. (2004)	
Mosses	Weissia condensa	Curly Beardless-moss	Wind taken as small seeds = 150 metres Greene, D. F. & Calogerpoulos, C. 2002. Measuring and modelling seed dispersal of terrestrial plants: in Bullock, J. M., Kenward, R. E. & Hails, R. S. 2002. Dispersal Ecology. Cambridge: Cambridge University Press.	150		34
Spiders	Pelecopsis radicicola	A money spider	Money spiders (Linyphiidae) are abundant in heterogeneous landscapes such as farm land. One reason for their persistence in these kinds of areas is the ability to move long distances by releasing a silken thread that allows them to be carried by the wind. http://www.findaphd.com/search/ProjectDetails.aspx?PJID=19701 However, low dispersal distances due to low wind velocities present additional complications for successful colonization. (Bonte et al, 2003)	250		

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (Ha)
True Flies (Diptera)	Doros profuges	Phantom Hoverfly	Assumed: http://www.sbes.stir.ac.uk/conservation_conference/documents/ERotheray.pdf; http://www.calsurv.org/sites/calsurv.org/files/u3/documents/Category_C.pdf#page=77	3000		
Vascular Plants	Cerastium pumilum	Dwarf Mouse-ear	Greene & Calogerpoulos, 2015	150		
Vascular Plants	Coeloglossum viride	Frog Orchid	Greene & Calogerpoulos, 2015	150		
Vascular Plants	Galium pumilum	A bedstraw	Greene & Calogerpoulos, 2031	150		
Vascular Plants	Gentianella anglica	Early Gentian	Greene & Calogerpoulos, 2034	150		
Vascular Plants	Helianthemum apenninum	White Rock-rose	Greene & Calogerpoulos, 2039	150		
Vascular Plants	Koeleria vallesiana	Somerset Hair-grass	Greene & Calogerpoulos, 2049	150		
Vascular Plants	Orchis morio	Green-winged Orchid	Greene & Calogerpoulos, 2049	150		
Vascular Plants	Trinia glauca	Honewort	Greene & Calogerpoulos, 2115	150		

Appendix 5: Heathland and Acid Grassland Species used for Generic Focal Species Development

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Ants, Wasps & Bees (Hymenoptera)	Tapinoma erraticum	Erratic Ant	http://jncc.defra.gov.uk/_speciespages/2642.pdf; Nuptial flights take place in June, although they may be postponed during colder years to July. http://en.wikipedia.org/wiki/Erratic_ant	200		
Birds	Caprimulgus europaeus	Nightjar	In foraging individual nightjars follow roughly the same flight path. The foraging range varies from 2 kilometres and can be up to 7 kilometres from the roost site (Cresswell, 1996). In the Thetford area it was found most flights were within 2 kilometres of nest sites. However, isolation of heathland patches has an effect on occupancy. One hundred and thirty of occupied patches were less than 100 metres , and 226 less than 500 metres from the nearest occupied patch. (Bright et al, 2007)	2000	For nightjars the average size of an occupied patch of heathland is 106 hectares. The minimum size containing more than one territory was 1.5 ha. (Bright et al, 2007).	106
Birds	Sylvia undata	Dartford Warbler	Van der Berg et al, 2001. Adult Dartford warblers are faithful to their territories and move at most 4.5 km. Juveniles disperse up to 6km in England. Territory size 2 to 3ha (Shirihai et al, 2010)	4500	Territory size 2 to 3ha (Shirihai et al, 2010)	75
Butterflies & Moths (Lepidoptera)	Celaena haworthii	Haworth's Minor	It has been demonstrated that the average dispersal distance of a moth is related to its wingspan. The furtherest distance travelled was by a setaceous Hebrew character moth at 1170 metres. The setaceous Hebrew character moth has a wingspan of between 35 and 42mm (Dulieu et al, 2007) Based on this the Haworth's minor moth (Wingspan 25-32 mm http://ukmoths.org.uk/show.php?bf=2367) is likely to have a dispersal range of about 620 metres.	620		
Butterflies & Moths (Lepidoptera)	Chesias rufata	Broom-tip	The broom-tip moth has a wing span of between 28 and 32 mm (http://ukmoths.org.uk/show.php?bf=1731) - dispersal distance estimated from Dulieu et al, 2007	680		
Butterflies & Moths (Lepidoptera)	Cyclophora pendularia	Dingy Mocha	The dingy mocha moth has a wing span of between 26 and 29 mm (http://ukmoths.org.uk/show.php?bf=1675) - dispersal distance estimated from Dulieu et al, 2007.	570		

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Butterflies & Moths (Lepidoptera)	Melitaea athalia	Heath Fritillary	Adult heath fritillaries are extremely sedentary, and at two small study sites the mean daily range within a day was 30 to 33 metres for females and 46 to 83 metres for males. In three larger study sites the mean range over sampling periods of up to 20 days was 84 to 214 metres, but there was no consistent difference between the sexes. Low levels of migration were regularly observed between colonies, over distances of up to 1 kilometre. (Warren, 1987; Asher et al, 2001)	1000	The heath fritillary can breed in areas of less than 2 hectares of suitable habitat (Warren, 1997). Minimum area of 5 ha is used for woodland reintroductions in Kent (Holloway et al, 2003)	5
Butterflies & Moths (Lepidoptera)	Rheumaptera hastata	Argent and Sable	The argent and sable moth has a wing span of between 34 and 38 mm (http://ukmoths.org.uk/show.php?bf=1787) - dispersal distance estimated from Dulieu et al, 2007.	960		
Butterflies & Moths (Lepidoptera)	Stilbia anomala	The Anomalous	The anomalous moth has a wing span of between 29 and 36 mm (http://ukmoths.org.uk/show.php?bf=2394) - dispersal distance estimated from Dulieu et al, 2007.	800		
Butterflies & Moths (Lepidoptera)	Xestia agathina	Heath Rustic	The heath rustic moth has a wing span of between 28 and 36 mm (http://ukmoths.org.uk/show.php?bf=2394) - dispersal distance estimated from Dulieu et al, 2007.	775		
Butterflies & Moths (Lepidoptera)	Xestia castanea	Neglected Rustic	The neglected rustic moth has a wing span of between 36 and 42 mm (http://ukmoths.org.uk/show.php?bf=2394) - dispersal distance estimated from Dulieu et al, 2007.	1100		
Fungi	Hygrocybe turunda	A basidiomycete fungus	Spore dispersal to downwind to distance of about 100m is easily demonstrable (Carlile, M. J., Warkinson, S. C., & Gooday, G. W. 2001. The Fungi. London: Academic Press)	150		
Hoppers (Homoptera)	Aphrophora alpina	A froghopper	Mean distance between occupied patches in a metapopulation of froghoppers was 221.5 +/- 401.3metres (Biedermann, 2000).	600		
Hoppers (Homoptera)	Macrosteles quadripunctulatus	A leafhopper	Biedemann (2000)	600		
Hoppers (Homoptera)	Scleroracus decumanus	A leafhopper	http://www.jcronin.biology.lsu.edu/biograph/publications/Planthopper%20movement%202003.pdf	100		

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Lichens	Cladonia convoluta	A lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns.	20		
Mosses	Dicranum spurium	A moss	Wind taken as small seeds = 150 metres ((Greene & Calogeropoulos, 2002)	150		
Reptiles	Vipera berus	Adder	There is a migration between winter and summer habitat, which can be separated by distances from 500 metres to over 2 kilometres. In some locations they may remain in a circumscribed area. (Beebee & Griffiths, 2000)	2000	A high population is regarded as being over 400 individuals to avoid long term in-breeding. On an island off the west coast of Sweden population fluctuated between 10 and 200 adders. Adder populations follow the trend in field vole populations. Studies in Europe have indicated that on average adder density is between 1 and 12 snakes per hectare. (Atkins, 2005; Madsen et al, 1999) A population of >20 is considered exceptional. At 4 per hectare	100
True Flies (Diptera)	Pelecocera tricincta	A hoverfly	Assumed: http://www.sbes.stir.ac.uk/conservation_conference/documents/ERotheray.pdf	3000		
Vascular Plants	Chamaemelum nobile	Common Chamomile	Greene, D. F. & Calogerpoulos, C. 2002. Measuring and modelling seed dispersal of terrestrial plants: in Bullock, J. M., Kenward, R. E. & Hails, R. S. 2002. Dispersal Ecology. Cambridge: Cambridge University Press.	150		
Vascular Plants	Cuscuta epithymum	Common or Lesser Dodder	Parasite	150		
Vascular Plants	Euphrasia anglica	An eyebright	Greene. & Calogerpoulos, 2002	150		

Taxonomic group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Vascular Plants	Filago vulgaris	Common Cudweed	Greene & Calogerpoulos, 2025	150		
Vascular Plants	Genista anglica	Petty Whin	Greene & Calogerpoulos, 2033	150		
Vascular Plants	Viola canina subsp. Canina	Heath Dog-violet	Greene & Calogerpoulos, 2123	150		
Vascular Plants	Viola lactea	Pale Dog-violet	Greene & Calogerpoulos, 2124	150		

Appendix 6: Fen, Marsh and Swamp Species used for Generic Focal Species Development

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Amphibian	Triturus cristatus	Great crested newt	*Dispersal distance sourced from Watts et al. (2005a) found in Eycott (2007)*	1000	10 m2 - 750 m2. MVA sourced from Watts et al. (2005a) found in Eycott (2007).	0.075
Beetles (Coleoptera)	Agonum scitulum	A ground beetle	*A. scitulum* is a species of lowland riparian margins and fens with dense wetland vegetation. http://jncc.defra.gov.uk/_speciespages/2010.pdf, 200 metres based on movements recorded for the ground beetle *Abax ater* (Mader, 1984).	200		
Beetles (Coleoptera)	Amara strenua	A ground beetle	Although reputed to be a species of coastal saltmarshes, this species is in fact associated with the floodplains of large rivers and is not halophilous (P. Hammond, pers. comm.). However, most British records are for coastal localities, grazing marshes or other (generally moist) grassland habitats. http://www.essexfieldclub.org.uk/portal/p/Species+Account/s/Amara+strenua Mader, 1984.	200		
Beetles (Coleoptera)	Bagous nodulosus	A weevil; Flowering Rush Weevil	Flightless (Chinnery, 2007). Found on Levels only in UK	200		
Beetles (Coleoptera)	Hydrochara caraboides	Lesser Silver Water Beetle	Lesser Silver Water Beetles fly readily (Shirt, 1987). Swedish research reported water beetles captured far from water during periods of dispersal, up to 420 metres in an agricultural landscape (Lundkvist et al, 2002).	420		
Beetles (Coleoptera)	Hydrochus ignicollis	A water beetle	Lundkvist et al, 2002	420		

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Beetles (Coleoptera)	Hydrophilus piceus	Great Silver Water Beetle	Favours late succession grazing marsh ditches. Lundkvist et al, 2002; Strong flying - Has been found on a North Sea oil rig (New. 2010)	420		
Beetles (Coleoptera)	Laccornis oblongus	A water beetle	Lundkvist et al, 2002	420		
Beetles (Coleoptera)	Panagaeus cruxmajor	Crucifix ground beetle	Appears to prefer habitats that are periodically inundated, such as floodplains and dune slacks. Many populations in Eire and on mainland Europe are associated with tall sedge fens that, either through grazing or inundation, are open in character above a bare muddy substrate. However, the specimens found in Sussex were on part of a river meander within the valley floodplain.http://www.arkive.org/crucifix-ground-beetle/panagaeus-crux-major/#text=Habitat; Mader, 1984.	200		
Birds	Acrocephalus scirpaceus	Reed Warbler	Dispersal distance sourced from Paradis et al. (1998) found in Sutherland et al. (2000)	271000	MVA sourced from Catchpole (1972) found in Bowman (2003)	0.03

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Birds	Botaurus stellaris	Great Bittern	The bittern is a partial migrant driven by winter weather conditions. Males tend to be faithful to territories but may move to other sites during the winter. They can relocate to different parts of the marsh or then disperse at least 15 kilometres (White et al, 2006)	N/A	A min area of 2 ha was used for reintroduction of the Bittern in Bavaria (White et al, 2006) The average lengths of reed edge next to open water (60%) and open ditches (40%) inside home ranges were 400 m per ha. Home range size was driven by available area of reed fringed open water. Radio-tracking of males, identified the theoretical home range of a booming male as including 3.93 ha of wet reedbed, 1.96 ha of cut reeds, 0.78 ha of open water, 0.82 ha of meadow and 0.03 ha of dry reedbed (White et al, 2006) On larger, continuous sites, booming territories usually form single units. On more fragmented sites one male can occupy several units of habitat. Male home ranges can be multi-centric; made up of 1–4 small nuclei within a larger area. Males are territorial and the average home range size is 20 hectares (White at al, 2006)	20

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Birds	Circus aeruginosus	Marsh Harrier	Marsh harriers require open freshwater wetlands with dense, tall vegetation (particularly reedbeds) for nesting. They favour brackish or freshwater equally and occur on marshes, ponds, lakes, lagoons and riverbanks. In some locations, they have adapted to drier habitats and breed in hedges and fields. In England and Scotland they breed in Reedbeds. Hardey et al, 2009; Fernández, & Azkona. 2003; Clarke, 1995) Migrant to Africa during the winter (Holden & Cleeves, 2002).	N/A	For Marsh Harrier the reedbed nesting site must form part of a range of productive hunting habitats extending to 100 ha or more, although the size of the bed itself may be as small as 5 ha. http://wildpro.twycrosszoo.org/S/00Ref/bookscontents/bookref93wetlandsindustrywildlife/chapter10.htm	100
Birds	Cygnus Olor	Mute swan	Dispersal distance sourced from Ciaranca et al. (1997) found in Sutherland et al. (2000)	64000	22000 m2. MVA sourced from Ciaranca et al. (1997) found in Bowman (2003)	2.2
Birds	Emberiza schoeniclus	Reed Bunting	The maximum observed foraging distance was 288 m but the 100-m radii included 87% of all foraging observations. Rank and emergent vegetation accounted for 32% of territories, 73% of nest-sites and 78% of foraging for Reed Buntings. Much rank and all emergent vegetation is associated with wetland features such as gravel pits, ponds and streams.(Brickle & Peach, 2004)	300	The median occupancy of reed buntings in marshes and ditches is 2.94pairs / ha in Poland (Surmaki, 2004) based on Allen et al (2001) this indicates that an area of 8.5 hectares would be required to support a population	8.5
Birds	Panurus biarmicus	Bearded Tit	Range widely between nesting areas and feeding areas (Winfield Gibbons et al, 1993) Extremely sedentary although some birds disperse from the breeding areas in September and October. http://www.birdguides.com/species/species.asp?sp=133001 Juveniles do not disperse more than a few hundred metres from their nests, and tended lo congregate in a preferred area. (Marin et al, 1994)	500	On Lake Valence in Hungary bearded tits occurred in all reed beds of 9 hectares. The smallest occupied reed island in Lake Valence was 0.03 hectares. Bearded tit territory size was 0.05 hectares. (Baldi, 2004) In the UK bearded tits breed regularly in reedbeds over 2 ha. (Hatchwell et al, 2001)	20

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Butterflies & Moths (Lepidoptera)	Boloria selene	Small Pearl-bordered Fritillary	Dispersal distance sourced from Stewart & Bourn (2003), found in paper unpublished Scottish Natural Heritage report by Robert Briers. The small Pearl-bordered Fritillary is considered near threatened by the Biodiversity Action Plan as of April 2014. These are Taxa which do not qualify for Lower Risk (conservation dependent), but which are close to qualifying for Vulnerable.	800	500 m2 - 85,000 m2. MVA sourced from Stewart & Bourn (2003) found in an unpublished Scottish Natural Heritage report by Robert Briers	8.5
Butterflies & Moths (Lepidoptera)	Rhizedra lutosa	Large wainscot	It has been demonstrated that the average dispersal distance of a moth is related to its wingspan. The furtherest distance travelled was by a setaceous hebrew character moth at 1170 metres. The setaceous hebrew character moth has a wingspan of between 35 and 42mm (Dulieu et al, 2007) Based on this the large wainscot moth (Wingspan 42 -50mm http://ukmoths.org.uk/show.php?bf=2375) is likely to have a dispersal range of about 1200 metres.	1200		
Caddis Flies (Trichoptera)	Grammotaulius nitidus	A caddis fly	650 metres up to 1845 metres from the waterbodies but in woodland and moorland habitats 10–20 metres. (Kovats et al, 1996; Petersen et al, 2004)	650		

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Dragonflies and Damselflies (Odonata)	Coenagrion pulchellum	Variable Damselfly	Stagnant or slow moving water such as grazing-marshes, ditches, ponds, lakes and canals which are well vegetated which is common in the Levels and Moors. http://www.erdragonflies.co.uk/yorkshire/blog/wordpress/?p=503 We used capture-mark-recapture techniques to study dispersal behaviour of seven species of odonates breeding on a network of 11 small ponds in Cheshire, U.K. Ponds varied from 30 to 860 m apart. We found surprisingly high rates of dispersal between ponds, with 10–47% per species of recaptured individuals moving from their natal pond. The mean probability of dispersal differed significantly among species but the relationship between the probability of dispersal and distance moved consistently followed a simple negative exponential curve for all species. Most individuals stayed at their natal pond, but a few moved long distances. (Conrad et al, 1999)	1000		

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Grasshoppers and Crickets (Orthoptera)	Stethophyma grossum	Large Marsh Grasshopper	Considered extinct in the Somerset Levels and Moors Both covered little distances within their mean range size of 1.8 ha; the median distances were 36.91 m for males and 26.65 m for females. Sub-populations of species in longstanding naturally isolated habitats, which habitat conditions have been stable; evolved low dispersal with little movements which are routine movements to find mating partners or food (Bönsel & Sonneck, 2011) The few investigations of movement of S. grossum have suggested a low dispersal behaviour (Marzelli 1994; Sorens 1996; Malkus 1997) with covered distances of 250 m on average and of 1500 m at most (Griffioen 1996) In Germany, mark–release–recapture experiments with S. grossum over one season have revealed that adjacent areas were not colonised by the grasshopper if these were surrounded by trees. Newly created habitats suitable for S. grossum could be colonised if they lay within distances of 400 m and if they were free of any barriers like trees or roads (Marzelli 1994).	400	Not sourced. However, despite that the peatland meadow was all over covered with homogenous vegetation in a study carried out by Bönsel & Sonneck (2011) only 6% (1.8 ha) of the whole area (30 ha) were occupied by *S. grossum*.	2
Hoppers (Homoptera)	Aphrodes albiger	A leafhopper	http://www.jcronin.biology.lsu.edu/biograph/publications/Planthopper%20movement%202003.pdf	100		
Hoppers (Homoptera)	Chloriona dorsata	A planthopper	Most planthoppers are week flyers and disperse distances of 1-3 km. (Denno & Roderick,1990)	1000		
Hoppers (Homoptera)	Paraliburnia clypealis	A planthopper	Most planthoppers are week flyers and disperse distances of 1-3 km. (Denno & Roderick,1990)	1000		
Hoppers (Homoptera)	Stroggylocephalus livens	A leafhopper	http://www.jcronin.biology.lsu.edu/biograph/publications/Planthopper%20movement%202003.pdf	100		

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Liverworts	Pallavicinia lyellii	Veilwort	Fertilisation occurs and a 'sporophyte' develops this structure remains attached to the plant. The sporophyte releases spores which disperse and develop into a new plant http://www.arkive.org/veilwort/pallavicinia-lyellii/ Spores are taken by the wind and assumed as for small seeds = 150 metres ((Greene & Calogeropoulos, 2002)	150		
Molluscs	Anisus vorticulus	Little Whirlpool Ram`s-horn Snail	It often floats on the surface amongst duckweed *Lemna* spp. It shows a preference for ditches or channels that are greater than 3m in width and over 1m in depth with a diverse flora but with moderate emergent vegetation. Ditches that are either completely cleared of vegetation or are choked with weed and silt are unsuitable. http://www.naturalengland.org.uk/Images/wmlg09_tcm6-4551.pdf Active upstream movement for most snails is 0.3 to 1.0km per year (Kappes, & Haase, 2012)	300		
True Flies (Diptera)	Odontomyia ornata	Ornate brigadier soldier fly	Soldier flies are week fliers. http://entomology.cornell.edu/cals/entomology/extension/vet/upload/Common_pest_fly_factsheet.pdf	250		
True Flies (Diptera)	Syndyas nigripes	A fly	Related to wetlands and especially peatlands where it can be abundant locally. http://www.artsportalen.artsdatabanken.no/Rodliste2010/Vurdering/Syndyas+nigripes/50954 Assumed similar dispersal capability to house fly. For house flies dispersing were recorded that 85 to 95% within 3.2 kilometres (Nazni *et al*, 2005; Stafford, 2008)	3200		

Taxonomic Group	Species (Scientific name)	Species (Common name)	Dispersal Range Source	Dispersal Range (metres)	Minimum Viable Area Source	MVA (ha)
Vascular Plants	Carex lasiocarpa x riparia (C. x evoluta)	A sedge	Greene & Calogerpoulos, 2008	150		
Vascular Plants	Juncus compressus	Round-fruited Rush	Greene & Calogerpoulos, 2008	150		
Vascular Plants	Lathyrus palustris	Marsh Pea	Greene & Calogerpoulos, 2008	150		
Vascular Plants	Oenanthe fistulosa	Tubular Water-dropwort	Greene & Calogerpoulos, 2008	150		
Vascular Plants	Peucedanum palustre	Milk-parsley	Greene & Calogerpoulos, 2008	150		
Vascular Plants	Sium latifolium	Greater Water Parsnip	Greene & Calogerpoulos, 2008	150		
Vascular Plants	Stellaria palustris	Marsh Stitchwort	Greene & Calogerpoulos, 2008	150		

Appendix 7: River and Stream Species from the Somerset Priority Species List

Taxonomic Group	Species (Scientific name)	Species (Common name)	Description of Core Area	Definition of Core Area	Core Area Length (metres)[8]	Period of Record Validity (Years)
Birds	Alcedo atthis	Kingfisher	Kingfisher's breeding and feeding territories are separate and both are defended. There are no fixed rules about the size of territories, as it will vary according to the population and the availability of fish. Each bird would require at least 1 kilometre of river and some territories may cover from 3 to 5 kilometres, which may include nearby lakes and side streams. (Boag, 1982) They pair in February or March and form breeding territories usually between 1 and 1.5 kilometres long (Holden & Cleeves, 2002).	Breeding territory. Kingfishers are reliant on river bank structure in which to construct their burrows.	2000	Water body with record of breeding kingfishers in the last 10 years. Kingfishers can live to 10 years (Hume, 2007).
Birds	Riparia riparia	Sand Martin	Adult birds foraging along the Sacramento River typically forage within 50 to 200 meters of the colony location (Garrison 1998), and the normal maximum foraging distance can be as great as 8 to 10 kilometres (Mead 1979) http://www.yoloconservationplan.org	Breeding territory. Sand martins are reliant on bank structure in which there are holes, either natural or manmade.	200	Water body with record of breeding sand martins in the last 10 years. Sand martins can live to 5 years (Hume, 2007).

[8] i.e. a length of 2000 metres would be 1000 either side of the recorded occurrence but may be adjusted in relation to the record according to local circumstances

Taxonomic Group	Species (Scientific name)	Species (Common name)	Description of Core Area	Definition of Core Area	Core Area Length (metres)[8]	Period of Record Validity (Years)
Crustaceans	Austropotamobius pallipes	Freshwater White-clawed Crayfish	White-clawed crayfish are able to spread along a watercourse for a distance of at least 3000 meters, maintaining the genetic homogeneity within the population. While activity was low during the winter, crayfish were able to spread up to 830 meters downstream and 546 meters upstream in 15 days during the summer. These authors also recorded individuals having covered 2439 meters between June and August. All these studies tend therefore to argue that crayfish are able to scatter over relatively large distances along streams, downstream as well as upstream. In one stream the distribution of crayfish in the first part of the brook (3 km) was not regular. The species was distributed among nine patches, representing 1700 metres of the brook (i.e. 57% of the 3 km area for A. Pallipes). (Broquet et al, 2002; Bubb et al, 2007)	Presence in watercourse	3000	5
Fish	Anguilla anguilla	Common Eel	The European eel breeds in the sea and migrating to freshwater in order to grow before returning to the sea to spawn. It is thought that all European eels spawn in the Sargasso Sea. http://www.arkive.org/european-eel/anguilla-anguilla/ Habitats of eels are extremely variable. They are found in freshwater and saltwater, lakes, ponds, marshes, rivers and estuaries (Bruijs & Durif, 2009). Eel migration through a catchment is hindered by major weirs upstream. Density decreases the further distance from the estuary of the river. (Aprahamian et al, 2007)	Not identified		

Taxonomic Group	Species (Scientific name)	Species (Common name)	Description of Core Area	Definition of Core Area	Core Area Length (metres)[8]	Period of Record Validity (Years)
Fish	Cottus gobio	Bullhead	The majority (61-72%) of tagged bullheads recaptured during the different sampling occasions were found at or near 10 m) their initial tagging site. The other re-sighted specimens however had covered distances between 20 and 270 m. There were no significant indications of seasonal differences in bullhead movement behaviour. (Knaepkens et al, 2006)	Presence in watercourse	500	20
Fish	Salmo salar	Atlantic Salmon	Length of spawning ground considered. Five transects at 10 metres intervals are considered to be needed for a HSI model (Stanley & Trial, 1995). Fifty metres is approximately the extent of spawning rounds in a study in Dorset and on the Dee (Moir et al, 2005) 200 metres is added for recording error.	Area of spawning. Section of main watercourse mapped for 125 metres either side of record.	250	20
Fish	Salmo trutta	Brown/Sea Trout	Smaller brown trout(<340 mm TL) had mean home ranges of 95 m and 28 m. (Belica, 2007)	Area of spawning. Section of main watercourse mapped for 125 metres either side of record.	250	20
Lichens	Collema dichotomum	River Jelly Lichen	Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns. Occupancy Not sourced therefore assumed Core Area of 50 metres plus 200 metres to allow for recording error.	Presence in watercourse	250	20

Taxonomic Group	Species (Scientific name)	Species (Common name)	Description of Core Area	Definition of Core Area	Core Area Length (metres)[8]	Period of Record Validity (Years)
Liverworts	Dumortiera hirsuta	Dumortier`s Liverwort	Occurs on waterfalls and cascades - on the edges where it drips; high humidity; shaded (www.naturalengland.org.uk/.../NERR024%20Rivers_tcm6-16015.xls).Spores are dispersed by the wind (http://science.**jrank**.org/pages/3968/Liverwort-Spore-dispersal.html.). For small seeds wind this can be 150 metres (Greene & Calogeropoulos, 2002). Core area would be the waterfall or cascade with which is associated. Assumed occupancy of 50 metres.	Presence in watercourse	50	20
Mammals	Lutra lutra	Eurasian Otter	Dog otters require about 20 kilometres of lowland river as territory bitch requires about 11 kilometres (Wayre, 1979). Estimates for area of water occupied of vary between 2 hectares and 50 hectares per otter. This is equivalent to one individual every 3–50 km of stream (median value of one otter per 15 km of stream). (Chanin, 2003) 15 to 20 kilometres long in Somerset (pers. comm. James Williams, Somerset Otter Group). Disturbance distance around otter holt used – 200 metres	Buffer recorded natal holts by 1.2km and include watercourses and 100 buffer within the radius	400	5 (surveyed annually by Somerset Otter Group)

Taxonomic Group	Species (Scientific name)	Species (Common name)	Description of Core Area	Definition of Core Area	Core Area Length (metres)[8]	Period of Record Validity (Years)
Mammal	Arvicola amphibius	Water Vole	The size and extent of water vole populations is determined by the size and quality of habitat available as well as the presence of American mink (*Mustela vision*), which is major predator of the species. Densities of water voles can vary with habitat type and season. Estimates of population density along watercourses for water voles range from 2.4 per 100 metres in West Lancashire; 3.3 per 100 metres in the North Yorkshire Moors; to 6.1 per 100 metres in the Brue marshes, Norfolk; and to 14 per 100 metres at Slimbridge. (Strachan & Moorhouse, 2006) In Scotland the length of this territory ranged between 25 and 47 metres. Elsewhere it is reported that female territories extend between 30 and 150 metres. Males do not defend territories, with a larger specimen having a larger home range and more females within it. In Oxford a male's home range was around 800 metres. Mean distance between colonies is 500 metres overland. In lowland areas populations of water voles can be very large, frequently containing hundreds of individuals. However, these often subdivide into colonies of smaller numbers. Very small populations are vulnerable to extinction through fluctuations in annual breeding rates, presence of predators and environmental factors such as flooding. A population can experience a 70% loss of numbers. Therefore, a loss to a population of 10 would be 3 individuals left whereas a population of 100 would leave 30 voles. A minimum viable population is therefore likely to be 30 to 40 individuals at the beginning of the breeding season and in excess of 100 individuals at peak breeding season occupying 1.5 to 2 kilometres of good quality habitat. Smaller populations are viable if not spatially isolated. (Strachan & Moorhouse, 2006)	Presence of colony	1600	10

Taxonomic Group	Species (Scientific name)	Species (Common name)	Description of Core Area	Definition of Core Area	Core Area Length (metres)[8]	Period of Record Validity (Years)
Mammals	Myotis daubentonii	Daubenton's Bat	Forage almost exclusively over water within 3 kilometres of roost, but may travel up to 15 kilometres. 90% of breeding females have home ranges within a radius of 4 kilometres. Core areas within home ranges are dependent on the size of the water bodies (Boye& Dietz, 2005). Another study found that females range up to 6 to 10 kilometres. Each bat had 2 to 8 separate hunting grounds of between 0.1ha and 7.5 ha. (Dietz et al, 2009) Aggressive behaviour is demonstrated by defending these feeding patches, although many arrive in the same area together, they then forage singly or in pairs (Richardson et al, 2008).	Sections of watercourse mapped either side of maternity colony.	4720	Daubenton's bats live on average 4.5 years (Dietz et al, 2009) Records up to 15 years old are included.
Mayflies (Ephemeroptera)	Nigrobaetis niger	Southern Iron Blue Mayfly	The streamlined nymphs are found in clean streams and rivers, often amongst weed in riffles, at the river margins, or swimming in short bursts amongst stones. http://www.buglife.org.uk/Resources/Buglife/Documents/Baetis%20niger%20species%20dossier%20SD%20CM%20FINAL%20070711.pdf Occupancy Not sourced therefore assumed Core Area of 50 metres plus 200 metres to allow for recording error.	Area of oviposition. Section of main watercourse mapped for 125 metres either side of record.	250	25
Molluscs	Myxas glutinosa	Glutinous Snail	(Kappes et al, 2012) Occupancy Not sourced therefore assumed Core Area of 50 metres plus 200 metres to allow for recording error	Section of main watercourse mapped for 125 metres either side of record.	250	25
Molluscs	Pseudanodonta complanata	Depressed River Mussel	For bivalves movement is most likely below 0.1km per year upstream and 100 times this for downstream movements (Kappes et al, 2012) Occupancy Not sourced therefore assumed Core Area of 50 metres plus 200 metres to allow for recording error.	Section of main watercourse mapped for 125 metres either side of record.	250	25

Taxonomic Group	Species (Scientific name)	Species (Common name)	Description of Core Area	Definition of Core Area	Core Area Length (metres)[8]	Period of Record Validity (Years)
Stoneflies (Plecoptera)	Brachyptera putata	Northern February Red	Stoneflies were captured along stream corridors and had flown upstream a mean distance of 211 m; the net movement of the population (upstream + downstream) estimated from the midpoint of the labelled sections was 126 m upstream. (Macneale et al, 2005)	Section of main watercourse mapped for 200 metres either side of record of larvae.	400	25
Stoneflies (Plecoptera)	Isogenus nubecula	A stonefly	Macneale et al, 2005	Section of main watercourse mapped for 200 metres either side of record of larvae	400	25
Stoneworts	Nitellopsis obtusa	Starry Stonewort	Starry stonewort tends to occur at depths of 1-6 m in lakes or sluggish rivers. It is typically found in calcareouswater, often close to the sea, hinting at a preference for saline conditions. http://www.arkive.org/starry-stonewort/nitellopsis-obtusa/#biology Starry stonewort is also easily fragmented and these fragments could seemingly act as disseminules that could be important in the spread of the plant. http://www.wolverinelake.com/Documents/WMB_Documents_Charts_Etc/Starry_Stonewort_Lakeline_Report.pdf The area of occupancy has not been sourced. Assumed spread of 50 metres plus 200 metres for recording error.	Section of main watercourse mapped for 125 metres either side of record.	250	25
True Flies (Diptera)	Atrichops crassipes	A water snipe-fly	The larvae are found in pristine streams. The area of occupancy has not been sourced. Assumed spread of 50 metres plus 200 metres for recording error.	Section of main watercourse mapped for 125 metres either side of record of larvae	250	25

Taxonomic Group	Species (Scientific name)	Species (Common name)	Description of Core Area	Definition of Core Area	Core Area Length (metres)[8]	Period of Record Validity (Years)
True Flies (Diptera)	Chalcosyrphus eunotus	A hoverfly	http://www.sbes.stir.ac.uk/conservation_conference/documents/ERotheray.pdf; The area of occupancy has not been sourced. Assumed spread of 50 metres plus 200 metres for recording error	Section of main watercourse mapped for 125 metres either side of record	250	25