# MINERALS LOCAL PLAN

## Topic Paper 5: Restoration

## Annex

## Identifying and Mapping the Mendip Hills Ecological Network

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# 1. Introduction

1.1 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 nature, which guides development to the right location and enhances natural networks. It also 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*.'

1.2 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)

*1.3 '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.'*[1] Maintaining and improving habitat connectivity is important in ensuring the long-term survival of biodiversity in a fragmented landscape and with a changing climate.[2]

1.4 The National Planning Policy Framework[3] specifically states that local authorities should '…*identify and map components of the local ecological networks…'*

1.5 Policy SMP5: Restoration and After Use in the Minerals Local Plan states that proposals for aggregate sites should, '… *seek to contribute to and enhance the local environment by minimising impacts on and providing net gains for habitats, biodiversity… and providing gains that improve the resilience of ecological networks*.' It then sets out a series of criteria that developers

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[1] http://www.publications.parliament.uk/pa/cm201011/cmpublic/localism/memo/loc163.htm
[2] http://www.defra.gov.uk/statistics/environment/biodiversity/wdfg22_habconn/; http://www.snh.gov.uk/land-and-sea/managing-the-land/spatial-ecology/
[3] http://www.communities.gov.uk/publications/planningandbuilding/nppf

should follow in order to demonstrate that the policy is being met. These include:

- Minimise impacts to an acceptable level on and provide net gains in biodiversity, thereby contributing to the Government's commitment to enhance biodiversity including by establishing coherent ecological networks that are more resilient to current and future pressure;
- Contribute to the achievement of UK Biodiversity Action Plan and Local Biodiversity Action Plan habitat and species targets; and
- Demonstrate the consideration of and use of biodiversity offsetting using the biodiversity methodology developed by Somerset County Council.
- Provide for adaptation or mitigation to impacts of climate change on habitats, species and ecological networks.

1.6 The purpose of this report is to set out how the 'Ecological Networks' for the Mendip Hills 'National Character Area 141' of Somerset is established and where they are. The Mendip Hills is the focus of quarrying activity in Somerset and is the area which is most likely to be affected, with respect to habitat connectivity, by policy in the Minerals Local Plan.

1.7 The Mendip Hills Ecological Network is also 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. The Mendip Hills 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. It is a tool to assist with restoration master-planning (and inform the minerals planning process), enabling minerals development to contribute positively to the natural environment and benefit people in line with the Natural Environment White Paper and the National Planning Policy Framework.

1.8 The ecological network mapping, carried out in GIS will show the extent of habitat networks in the Mendip Hills and aid identification of areas which need restoration in order to restore their coherence. This will be used as an evidence base for the Minerals Local Plan in directing restoration and identify where development could affect an ecological network. One aim is to prevent further biodiversity loss occurring through fragmentation of an ecological network. The ecological network will also eventually guide habitat creation and / or restoration resulting from Biodiversity Offsetting.

# 2. Policy and Legislative Background to Ecological Networks

## Introduction

2.1 For Ecological Networks to be effective, they need to be implemented strategically, rather than on a piecemeal basis. References to the concept of networks in policy and strategy documents are important because they will give legislative and administrative back-up to the process. For example, there is a clear support for the concept of networks in the National Planning Policy Framework. It's also a way for local authorities to 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.[4]

## Government White Paper on the Natural Environment

2.2 The Government White Paper on the Natural Environment, The Natural Choice: securing the value of nature published in June 2011 includes provision for pilot projects using biodiversity offsetting as a method to halt the decline of biodiversity.

The Government wants to '…*create a resilient and coherent ecological network at a national and a local level across England*' and intends to put in place a clear institutional framework to support nature restoration including '…*strengthening support through the planning system including through biodiversity offsets*.'

2.3 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*.'

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[4] http://www.snh.gov.uk/land-and-sea/managing-the-land/spatial-ecology/policy-and-legislation/

## National Planning Policy Framework

2.4 The National Planning Policy Framework (Department for Communities and Local Government, 2012) [NPPF] sets out the Government's policy for biodiversity. The Framework includes policy which supports the development of ecological networks and indicates forward planning for biodiversity.

2.5 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 and enhancement of the natural environment.

2.6 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.

2.7 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***.'

2.8 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*.'

2.9 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[5], wildlife corridors and stepping stones that

[5] Within the Ecological Network for the Mendip Hills 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.

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

2.10 The Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (the 'Habitats Directive') is usually thought of in connection with the implementation of a series of protected sites - Natura 2000 sites, which include Special Protection Areas and Special Areas of Conservation. However, both Article 3 and Article 10 of the European Birds and Habitats Directives respectively 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.

2.11 Article 10 of the Habitats Directive 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 stepping stones (such as ponds or small woods) are essential for the migration, dispersal and genetic exchange of wild species*.'

2.12 Article 3 of the Birds Directive clearly makes reference to the need to undertake conservation actions outside of designated sites through: '*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*'.

2.13 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).

2.14 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.

2.15 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

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

2.17 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.

2.18 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*.' It then goes on to list the same specific features that are highlighted in Article 10 of the Habitats Directive.

2.19 It is also the County Council's responsibility, under Regulation 9, to ensure that the 'favourable conservation status' of local populations of EPS is maintained including the habitat to support them as defined by Article 1 of the Habitats Directive. Account also has to be taken with regard to populations under Regulation 41 that it is also an offence to deliberately disturb wild animals of EPS in such a way as to be likely to: '*affect significantly the local distribution or abundance of the species to which they belong*'.

## The Natural Environment and Rural Communities Act 2006

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

2.21 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.

2.22 Biodiversity offsetting requires ‘no net loss’ and ‘preferably a net gain of biodiversity’ In the NERC Act this is defined as, ‘*restoring and enhancing a population or habitat*’ (S.40 (3)) (Defra, 2009)

# 3. Habitat Connectivity and Fragmentation

## Introduction

3.1 Biodiversity underpins the provision of ecosystem services and a key feature of biodiversity is the functional relationship between species within an ecosystem. Some species within ecosystems are termed ‘keystone species’ because of their unique function and their loss would have highly damaging consequences including economically. (Kuttunen *et al*, 2007)

3.2 The goals of the Habitats Directive for species conservation require two basic conditions:

- Quality of habitat (allowing enough for reproduction)
- Habitat area (to prevent extinction by accident)

(Opdam *et al*, 2002)

3.3 Habitats have undergone considerable loss and fragmentation through human activity. Further habitat loss and fragmentation is regarded as a serious threat to biodiversity conservation, even though many habitat fragments are now protected or safeguarded by site designations, such as Sites of Special Scientific Interest and Local Wildlife Sites. (Watts *et al*, 2008)

3.4 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

3.5 The maintenance of species and the ecological functioning of landscapes are determined by the role that different patches of habitat play for different species. A patch is an area of distinct habitat and / or a resource used by a species. Patches can vary in the role they play in a species ecology, for example some may be used for breeding whilst others for foraging. The area between the patches is called the habitat matrix. Patches and habitat matrices are species specific. (Kuttunen *et al*, 2007)

3.6 Species are dependent on the existence of adequate habitat and resource patches and the ability to disperse amongst them. It is important that the area and quality of available patches is able to maintain a minimum viable population. (Kuttunen *et al*, 2007)

3.7 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)

3.8 The edge of a habitat patch is always adjacent to a different land use, and as a result it's often affected by '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

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

3.10 However, '*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)

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

3.12 Some species respond well to those changing conditions and they can be considered as 'edge species', whereas other species respond badly to an increase in edge area. 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)

3.13 The value of a large area of semi natural habitat outweighs its division into smaller areas where alterations, for example to light, hydrology and levels of disturbance can have a radical effect on species survival. 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. Road construction and widening would increase fragmentation effects. (Treweek, 1999; Evink, 2002; Seiler, 2002)

3.14 The reduction in habitat area would be less able to support a level of population that existed prior to the land use change and may result in inbreeding to genetic problems 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)

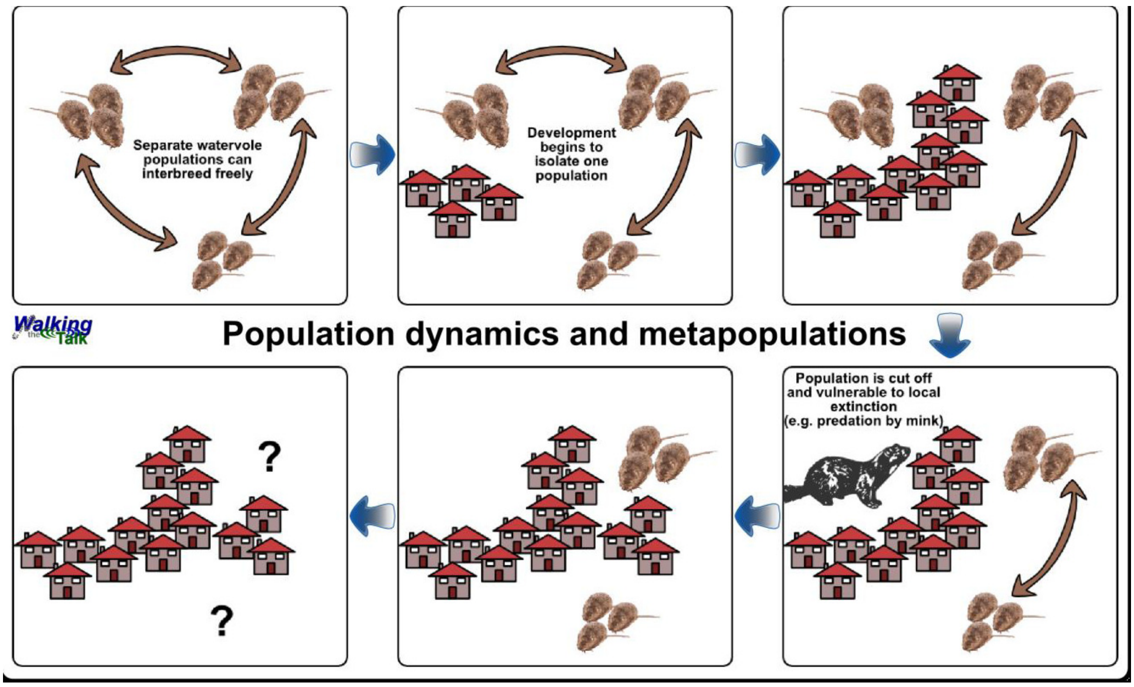
## Species Dispersal

3.15 The process of dispersal can allow species to colonise new areas or habitat patches. Individual animals or plant seeds move away from their birth area, or move from a zone that has a high population density to an area with a lower density. The overall ability of a species to disperse is likely to depend on a range of factors such as its mobility and reproductive ability. Dispersal ability will affect how sensitive a species is to habitat fragmentation. Species which have low dispersal abilities are likely to be more affected by fragmentation, especially if they also require a large area of habitat to survive. (Scottish Natural Heritage, 2010)

3.16 The long-term survival of species is strongly dependent on the movement of individuals through dispersal or migration 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)

3.17 A key issue in a fragmented landscape is the ability of species populations to survive in and move between small isolated habitat patches scattered within an urban and agricultural landscape. Research has shown that habitat size and wildlife corridors are of vital importance to nature conservation, and to thriving and diverse wildlife (English Nature, 1996; Dufek, 2001; Evink, 2002).

**Figure 1: Example of Fragmentation of a Metapopulation**




If the area between the two sub-populations becomes too hostile or difficult to cross, migration and genetic exchange between populations cannot take place, and the different populations will no longer be connected. That makes them more vulnerable to being wiped out by catastrophic events - for example, many populations of water vole in Scotland have been wiped out by the highly effective predation actions of American mink. Where habitat fragmentation has also occurred, the water voles are unable to travel from one sub-population to another, so they can't re-colonise areas that have been decimated by the mink. (Scottish Natural Heritage, 2010)

3.18 Some populations exist as metapopulations. This is a set of populations within a larger area where migration from one population to at least some other patches occurs (Kuttunen *et al*, 2007). This means that if one population is wiped out, the vacated habitat patch can be re-colonised by individuals from other populations within the wider meta-population. For example, water voles (*Arvicola fluvius*) are thought to function as a metapopulation with individuals moving between sub-populations in different parts of a river catchment. However, metapopulations are dependent on individuals being able to move from one population to another. See Figure 1 above. (Scottish Natural Heritage, 2010)

## Connectivity

3.19 Connectivity is a measure that describes how connected or spatially continuous a landscape matrix is or the degree to which the landscape facilitates or impedes movement among different habitat patches. Movement between patches can be ascertained by analysing landscapes from the species perspective. The nature and scale of these elements can vary widely between species. (Kuttunen *et al*, 2007)

3.20 There are two types of connectivity. These are:

- Structural Connectivity
- Functional Connectivity

### Structural Connectivity

3.21 A landscape is described as structurally connected when areas of habitat are physically joined together by a linking area of a similar habitat type, for example two woodland patches by a hedgerow. However, just because two areas of habitat are structurally connected, it doesn't necessarily follow that all species will be content to, or capable of moving between them. For example, the connecting linkage may be too small for an animal to feel secure passing along it, or it may receive too much direct sunlight for some plant species to thrive there. So although there may be a structural connection between two habitat patches, visible as a line on a map, it may not actually constitute a network. (Scottish Natural Heritage, 2010)

3.22 A review of evidence carried out by Davies and Pullin (2006) for species using hedgerows as corridors found that the use of such corridors may be influenced by other factors such as the type and spatial distribution of adjacent habitats and farming activity, the interaction between conspecifics and other species. In a study on woodland birds by Schippers *et al* (2009) it was found that linear elements were able to catch and guide dispersing animals resulting in higher connectivity between patches leading to higher metapopulation survival.

**Functional Connectivity**

3.23 Functional connectivity is where a species can move between the different habitat patches through an area of suitably managed matrix / surrounding land - resulting in the habitat patches being connected in practice for that particular species. Current land-use needs to be assessed in determining whether functional connectivity would exist for a species. (Scottish Natural Heritage, 2010)

## Climate Change

3.24 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]

3.25 It is likely that many species will need to change their current distributions to new sites and areas with suitable climatic conditions. The UK Biodiversity Partnership has suggested that '… *ecological networks should be established*

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

*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)

# 4. An Introduction to Ecological Networks

## Overview

4.1 The Mendip Hills Ecological Network is being developed in addition to statutorily designated sites, such as SSSI and SAC, and NGO nature conservation sites, as the network would contain the priority habitats that these sites are designated for in any case. The Mendip Hills 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.

4.2 Computer simulations have been used to model ecological networks over a range of landscape scales to target conservation action and evaluate habitat management options (Watts *et al*, 2007). A computer modelling application was used to develop the ecological networks for Mendip Hills. This chapter introduces the terms that are used in relation to this model.

## Terms Used in Describing the Ecological Network

***The following terms are used in describing the ecological processes related to the Ecological Networks:***

**Priority Habitats**

4.3 The Mendip Hills contain a number of habitats of principle importance (Section 41, The Natural Environment and Rural Communities (NERC) Act) or priority habitats that support similar species and that are structurally very similar. Priority habitats have been grouped together into three major groups (that were then modelled to produce three ecological networks). A fourth ecological network group – rivers and streams – was produced separately.

4.4 The three major habitat groups that were used to model separate ecological networks in the Mendip Hills[8] are:

- Broad-leaved Woodland
- Priority Grasslands (including calcareous, acid and neutral grassland)
- Heathland and Acid Grassland

[8] http://www.naturalengland.org.uk/Images/141_Mendip_Hills_tcm6-32151.pdf

4.5 For a full description of these habitats see Appendix 1.

**Network**

4.6 An ecological network is a joined-up group of natural and semi-natural habitats which is managed with the objective of maintaining or restoring ecological function, in order to conserve biodiversity[9]. Ecological networks are provided as a response to biodiversity decline, and aim to 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.

**Generic Focal Species**

4.7 In modeling the ecological network for each of the priority habitats identified in the Mendip Hills a Generic Focal Species is used for each. This is a conceptual species whose profile consists of ecological requirements reflecting the needs of real priority species present in Somerset. A Generic Focal Species should encompass most real species that need to be considered in forming the ecological network. (Eycott *et al*, 2007)

4.8 A Generic Focal Species is intended to serve as an 'umbrella' for native species (capturing many species ecological traits) and ecological processes in forming ecological networks. There is one Generic Focal Species for each of the priority habitat types modelled in the Mendip Hills.

4.9 Focal Species are also likely to have some form of conservation priority or are important ecologically. The Generic Focal Species used in establishing ecological networks in the Mendip Hills are derived from the ecological requirements of species listed on the Somerset Priority Species List[10] .

**Minimum Viable Area**

4.10 Minimum Viable Area refers to the smallest area of habitat that is likely to support a sustainable population of a species. In the Ecological Network the minimum habitat size used in modelling is based on an analysis of the

[9] Biodiversity is taken to encompass nationally and locally important and priority species and habitat

[10] http://www.somerc.com/downloads/

requirement of species requiring larger habitat patches to survive. Account is also taken of those species which survive in metapopulations of interconnected smaller habitat patches (e.g. see Hanksi, 1999).

**Maximum Dispersal Distance**

4.11 Maximum dispersal distance refers to the ability of a species to move through its ideal habitat in the landscape. In the Ecological Network the maximum dispersal distance used in modelling is based on an analysis of the ecological traits of Somerset priority species.

4.12 Background information on the ecological needs and traits of the species used to inform the development of the generic focal species for each priority habitat (including minimum viable area and dispersal distance) is found in Appendices 2 to 6.

**Permeability**

4.13 Permeability and permeability cost refer to the ability of a species to move or disperse through the landscape. Permeability of the landscape changes depending on the generic focal species used. For example a woodland species can pass with ease through woodland habitats where a grassland species would have difficulty. Different habitat types (both semi-natural and man-made) affect the ability of species to disperse (see the simplified table below).

**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 |

4.14 In modeling the ecological network for each Mendip priority 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 following terms are used in describing the components of the Ecological Networks:***

4.15 An Ecological Network comprises one or more individual networks in a landscape; at the heart of each is at least one core area of priority habitat, surrounded by matrix habitat, where matrix is used to describe other habitats that the generic focal species could disperse across.

**Core Areas**

4.16 Core Areas are patches of the priority habitat being modelled that are of sufficient size to support a viable population of the Generic Focal Species for that habitat.

**Network Habitats**

4.17 Comprise:

- Areas of matrix habitat that can be crossed by the generic focal species in moving between areas of core habitat

- Patches of the priority habitat being modelled that are smaller than the minimum size necessary to support a population of the generic focal species being modelled.

    - These patches of priority habitat can form **stepping stones** or **corridors** within the matrix habitat. They may form more or less continuous stretches of priority habitat that form structural corridors or they may be discrete “islands” of priority habitat that enable the generic focal species to move across the matrix habitat between core areas.

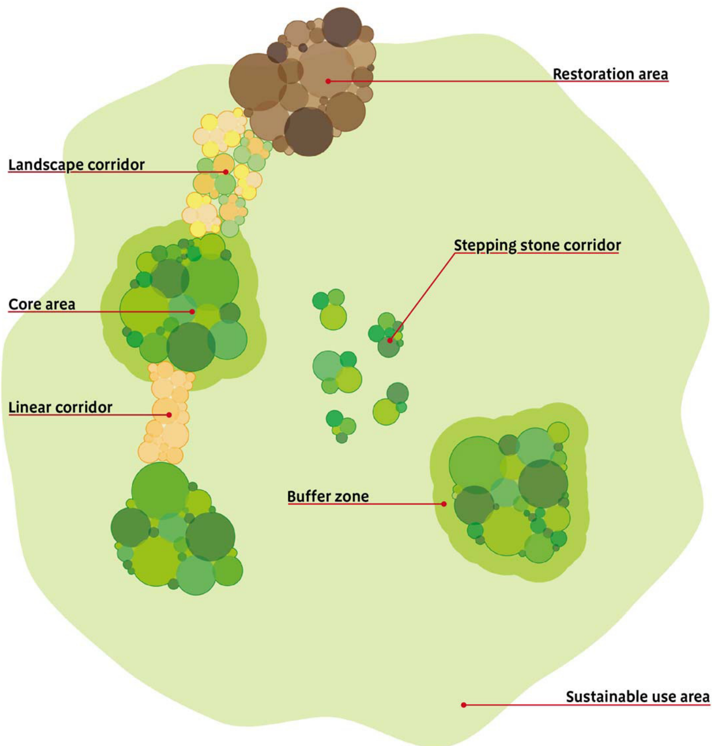
**Sustainable Use**

4.18 This comprises the majority of the landscape. The aim is to improve the permeability of the land surrounding the discrete ecological networks. This could be through agri-environment scheme options that can be tailored to suit local conditions and promote management of farmland that is environmentally sensitive.

### Restoration Areas

4.19 Restoration areas are designed to enhance connectivity, resilience and functioning of the ecological network. Opportunities for building the resilience of ecological networks are numerous including the creation of **buffer zones** around core areas e.g. an area of targeted land use that does not adversely affect the habitat of the core area or to mitigate damaging effects from intensive land use. For more information on Restoration Areas see section 7.2 below.

**Figure 2: Features of Ecological Networks (from Lawton *et al*, 2010)**



# 5. Modeling the Mendip Hills Ecological Network

## Introduction

5.1 Developing perfect ecological networks would depend on a detailed knowledge of every species' needs although we will probably never have enough ecological detail to do this. Modelling the networks using a computer programme is a practical, cost efficient way that enables us to produce indicative networks whilst, in the process, allowing the time to continue collecting data. It is important to note that ecological networks will continue to evolve and be updated on a rolling basis.

5.2 This chapter sets out how the indicative Mendip Hills Ecological Network was modeled in ArcGIS 9.2. Two methods have been used to construct the ecological network. These are:

- BEETLE least-cost network model[11]
- Analysis of Structural Connectivity of Rivers and Streams

5.3 The resulting network maps are included in this topic paper, supporting the Minerals Local Plan, in compliance with the National Planning Policy Framework.

## BEETLE Least-cost Network Model

5.4 The Mendip Hills Ecological Network uses 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)[12].

5.5 The tool models species-specific networks that extend from core areas, which are defined by a species' minimum viable area parameters. The extent of the network (outside of these core areas) is governed by a maximum dispersal distance parameter that determines the extent of network surrounding the core areas.

5.6 Landscape permeability in the model, or the degree to which the matrix facilitates or impedes movement, is incorporated through the use of a least-

[11] developed by Forest Research (Watts et al, 2010)
[12] http://www.forestry.gov.uk/fr/INFD-7S9ARR

cost distance function. The model achieves this by assessing the permeability of habitat, based on cost scores assigned to each field parcel in the geographic area being modeled, and then reducing the maximum dispersal distance of the species as the hostility or cost score of surrounding landscape matrix increases. The resolution of the output in terms of how large or small habitat patch sizes are included is set by a cell size parameter. For instance to pick up small areas of priority grassland a small cell size is required.

**Habitat Selection**

5.7 The first stage of modeling the Mendip Hills Ecological Network is the identification and definition of those habitat types forming the network.

5.8 The Mendip Hills contain a number of habitats of principle importance (priority habitats) that support similar species and that are structurally very similar. Priority habitats have been grouped together into three major groups that were then modelled to produce three ecological networks.

5.9 The three ecological networks modelled in the Mendip Hills[13] were:

- Broad-leaved Woodland
- Priority Grasslands (including calcareous, acid and neutral grassland)
- Heathland and Acid Grassland

5.10 A fourth ecological network group – rivers and streams – was produced separately. For a description of these habitats see Appendix 1.

**Source of Habitat Data**

5.11 Habitat data used in the Mendip Hills Ecological Network was derived principally from the Integrated Habitat Survey (IHS). 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. The full list of data sources used in the Mendip Hills Ecological Network is as follows:

[13] http://www.naturalengland.org.uk/Images/141_Mendip_Hills_tcm6-32151.pdf

- IHS data derived from Somerset Wildlife Trust's Mendip Hills Living Landscape field survey (2006-2012)
- IHS aerial photo interpretation from Somerset Environmental Records Centre (2006)
- Built environment data (roads, buildings, gardens etc) from OS Master Map

5.11 These three sources of information were merged into a single seamless dataset covering the entire Mendip Hills.

5.12 IHS contains over 400 habitat codes. All codes relating to the habitat type being modelled were selected to provide a GIS mapping layer called "**home habitat**". A home habitat layer is required for each of the ecological networks being modelled.

**Table 2: Home habitat selection**

*Italics denotes non-priority but species-rich habitat*

| Home Habitat | IHS Code | IHS Name |
|---|---|---|
| Priority 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 |
| | 'GC1' | Lowland calcareous grassland |
| | 'GC13' | Lowland calcareous grassland with acidic indicators |
| | 'GC14' | Heathy lowland calcareous grassland |
| | 'GC1Z' | Other lowland calcareous grassland |
| | 'GN1' | Lowland meadows |
| | 'GN12' | Lowland meadows with calcareous indicators |
| | 'GN13' | Lowland meadows with acidic indicators |
| | 'GN14' | Species rich lowland meadow |
| | 'GN1Z' | Less species rich lowland meadow |
| | 'GN31' | *Other neutral grassland-species rich* |
| | 'GN311' | *Species rich other neutral grassland with calcareous indicators* |
| | 'GN312' | *Species rich other neutral grassland without calcareous indicators* |
| | 'GN31Z' | *Other species rich neutral grassland* |

| Home Habitat | IHS Code | IHS Name |
|---|---|---|
| Heath and 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 |
| | HE0 | Dwarf shrub heath |
| | HE1 | European dry heaths |
| | HE3 | Lichen-bryophyte heaths |

| Home Habitat | IHS Code | IHS Name |
|---|---|---|
| Woodland | WB0 | *Broadleaved, mixed, and yew woodland* |
| | WB1 | *mixed woodland* |
| | WB2 | *scrub woodland* |
| | WB3 | *broadleaved woodland* |
| | WB32z | Other upland mixed ash woods |
| | 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 |
| | WB34z | Other wet woodland |
| | WB36 | Lowland mixed deciduous woodland |
| | WB363 | Lowland *Tileo-acerion* forests of slopes, screes and ravines |
| | WB36z | Other lowland mixed deciduous woodland |
| | WB3z | *Other broadleaved woodland* |

**Focal Species**

5.13 As landscape connectivity is species specific a Generic Focal Species needs to be developed for each of the networks being modeled. For each generic focal species the BEETLE least-cost network model requires the input of:

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

5.14 To ensure the Generic Focal Species act as umbrellas for as many “real” Somerset species as possible, a screening process to derive a realistic minimum viable area and a dispersal distance for each generic focal species was carried out on those species listed in the Somerset Priority Species List. These species and the screening process are listed in Appendices 2 to 6.

5.15 The model uses the minimum viable area parameter as a means of selecting the core areas of the ecological networks. The maximum dispersal distance parameter is adjusted by the model to reflect landscape permeability (see section 5.2.4 below). Where habitats adjacent to core areas are sufficiently permeable for the generic species to move across, the model will select these habitats to form part of the ecological network. If the habitat has a permeability cost that is too high (i.e. the landscape is hostile) then this will not form a significant part of the ecological network, regardless of actual geographic proximity. Table 3 gives a summary of the metrics for Generic Focal Species used in modeling the ecological network for the Mendip Hills.

**Table 3: Summary of Generic Focal Species Metrics**

| Network being modeled | Minimum Viable Area (hectares) | Maximum Dispersal Distance (metres) |
|---|---|---|
| Broadleaved Woodland | 20 | 800 |
| Priority Grasslands | 5 | 700 |
| Heathland and Acid Grassland | 20 | 500 |

### Landscape Permeability

5.16 In the Mendip Hills Ecological Network permeability values were based on a 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).

5.17 These scores were reviewed by Somerset Wildlife Trust and Somerset County Council and amended, where appropriate, to Somerset conditions. A new network habitat (Heathland and Acid Grassland) was added in place of Fen Marsh and Swamp to reflect local conditions. In the Mendip Hills field survey gathered more refined habitat information for grassland habitats than the “broad habitat” neutral grassland type used by Eycott *et al*. In Mendip priority grassland includes neutral, calcareous and acid grasslands and it was felt important to include all these in the modelling process, therefore the broad habitat scores for Eycott’s neutral grassland were amended to include all priority grasslands and reflect local conditions.

5.18 The model uses an ArcGIS map layer (a shape file) which is comprised of the relevant geographic area with each field parcel being assigned a permeability cost score specific to the generic focal species. The shape file is based on the cost scores in the following table.

**Table 4: Summary of Permeability Cost Scores**

| Habitat Type | IHS code equivalents | Permeability cost scores | | |
|---|---|---|---|---|
| | | Broad-leaved, Woodland | Priority Grassland | Heathland and Acid Grassland |
| Acid Grassland | GA: 0,1,11,12,13,14,1Z,Z | 4.44 | 2 | 2 |
| Bog | EO: 0,1,2,21,22,2Z,Z | 2.5 | 20 | 4.44 |
| Bracken | BR:0,1,Z | 1.82 | 4.44 | 4.44 |
| Broadleaved and Yew Woodland | WB: 0,1,2,3,31,32,321,32Z,33,331,3311,3312,3313,331Z,33Z,34,341,342,34Z,35,36,361,362,363,36Z,3Z | 1 | 10 | 10 |
| Calcareous Grassland | GC: 0,1,11,12,13,14,1Z,2,21,22 | 4.44 | 1 | 1.74 |
| Dwarf Shrub Heath | HE: 0,1,11,1Z,2,21,22,2Z,3,Z | 2.22 | 8 | 8 |
| Fen, Marsh, Swamp | EM: 0,1,11,12,1Z,2,21,22,3,31,311,312,3121,312Z,313,314,315,31Z,32,321,322,323,32Z,3Z,4,41,4Z | 2.5 | 6.67 | 6.67 |
| Inland Rock | RE (not RE21) | 5.45 | 10 | 10 |
| Montane | MH | 3.53 | 8 | 8 |
| Mosaic | OV | 2.22 | 5 | 5 |

| Habitat Type | IHS code equivalents | Permeability cost scores | | |
|---|---|---|---|---|
| | | Broad-leaved, Woodland | Priority Grassland | Heathland and Acid Grassland |
| Natural Shape Woody Linear Feature | LF:0,1,11,111,11Z,12,1 Z, | 2 | 5.71 | 5.71 |
| Neutral Grassland | GN | 4.44 | 1.74 | 1.74 |
| Arable and Horticulture | CR | 10 | 20 | 20 |
| Coniferous Woodland | WC | 3 | 20 | 15 |
| Improved Grassland | GI, GP0 | 10 | 6.67 | 6.67 |
| Road | LF:27, 271 | 10.91 | 40 | 40 |
| Urban | UR | 5 | 13.33 | 30 |
| Rivers and Streams | AR | 10 | 20 | 20 |
| Standing Open Waters and Canals | AS | 10 | 20 | 20 |
| Grassland Unimproved | GA: 0,1,11,12,13,14,1Z, Z. GC:0,1,11,12,13,14,1Z, 2, 21, 22. GN: 0, 1, 11, 12, 13, 14, 1Z, 2, 3, 31, 311, 312, 31Z. | N/A | 1 | 1 |
| Semi improved grassland | GN: 3Z. GU0 | 4.44 | 2 | 2 |
| Heath and Acid Grassland | HE: 0,1,11,1Z,2,21,22,2Z,3, Z. GA: 0,1,11,12,13,14,1Z,Z | N/A | N/A | 0 |
| Quarry Building Stone Aggregate | RE21 | 40 | 40 | 40 |

**Cell Size**

5.19 A resolution size is also used in the model. In the Mendip Hills this was set at a cell size of 2m in order that smaller or narrower map polygons are included, such as roads and rivers.

## Rivers and Streams Ecological Network

5.20 This ecological network was not modelled using the BEETLE least-cost network tool. The method used for the Rivers and Streams Ecological Network merely extracts watercourse polygons designated with the IHS codes beginning AR (Rivers and Streams) from OS Mastermap as the ‘home habitat’.

5.21 As this habitat is structurally connected it is considered to be a **Corridor** habitat that presents no barriers to movement for most riverine species I dentified in the Mendip Hills. Furthermore, the recorded presence of otters, included on the Somerset Priority Species List and a Focal Species for this habitat type, and with regard to their dispersal capability and habitat requirements, means that all river and streams in Somerset would be included in the habitat network.

5.22 Appendix 6 lists those species associated with rivers and streams from the Somerset Priority Species List. Within the Rivers and Streams ecological network sections of the corridor habitat are identified as **Core Areas** by the criteria given for individual Focal Species, i.e. recorded breeding site and the watercourse habitat used to support it. The parameters used are given in Appendix 6. Note that a Generic Focal Species is not used in identifying Core Areas in this case.

5.23 In mapping the network an 8 metre buffer of the watercourse polygons from OS Mastermap is included as part of Core Areas and the Habitat Network. This will allow for fringing bankside habitat which forms an important element in the functioning of a watercourse. This would also allow for burrows in river banks such as those used by kingfishers and water voles for example. It is also the specified distance for designating watercourses in the Local Wildlife Sites Guidance for Somerset (Biron, 2010).

# 6. Ecological Network Maps

6.1 The resulting networks are displayed. For clarity the four ecological networks that comprise the Mendip Hills Ecological Network have been combined for display in two maps as follows:

**Figure 3: Broadleaved woodland and rivers and streams ecological networks**

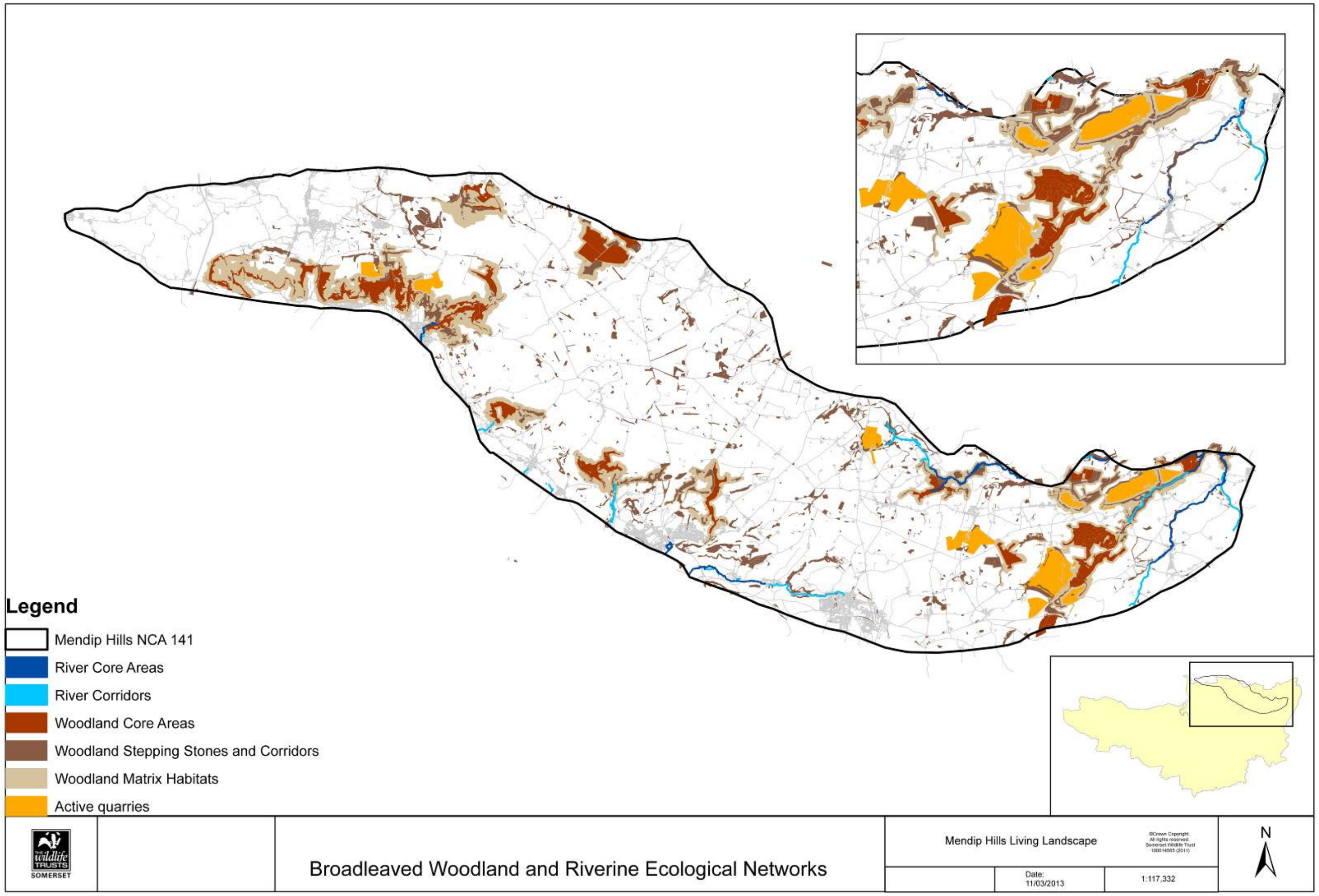


**Figure 4: Heath and Acid Grassland Ecological networks**

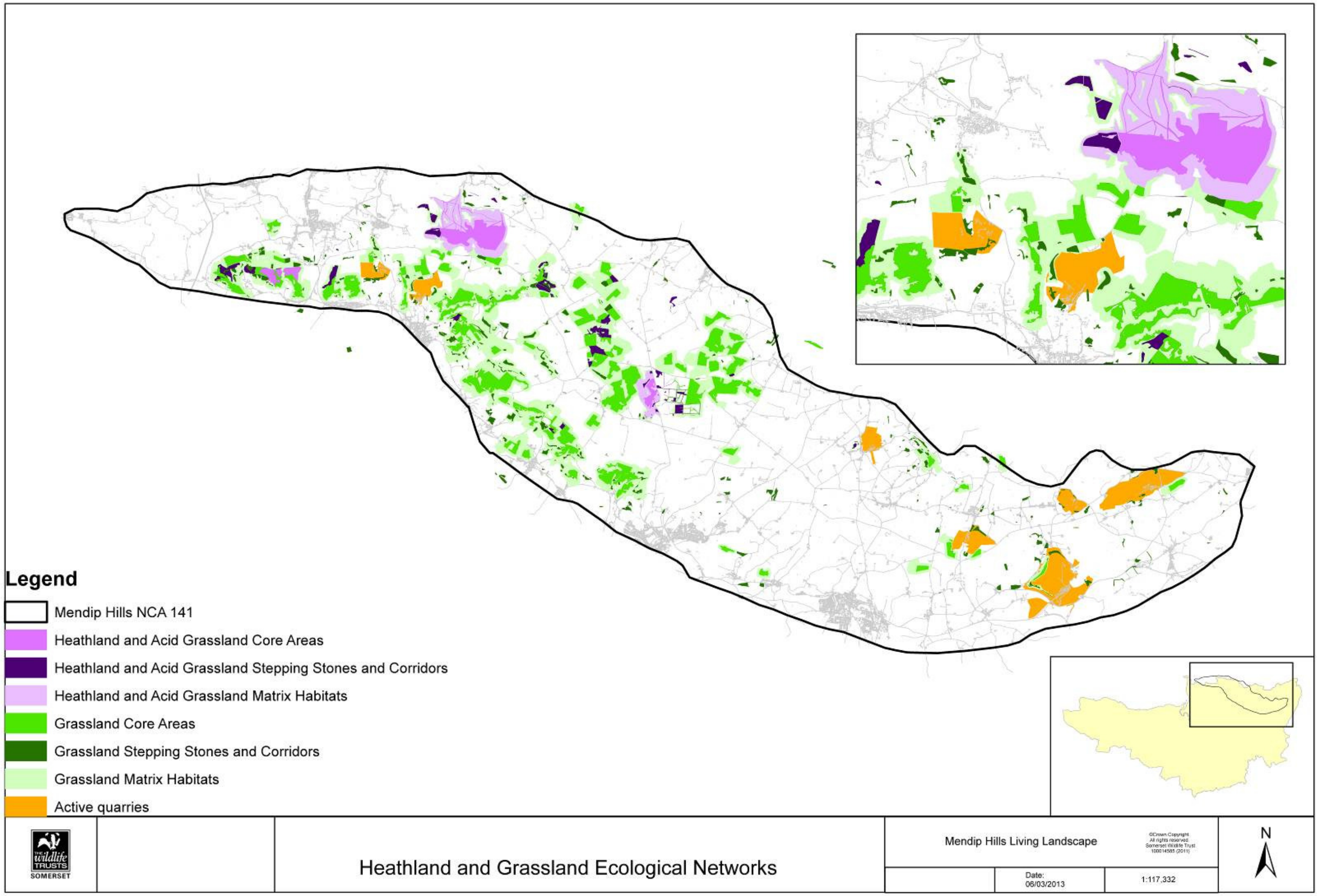


**Table 5: Summary of networks results**

**Grassland Networks**

| Network ID | Network Area (Ha) | Core area Count | Core area Area (Ha) |
|---|---|---|---|
| 1 | 668.29 | 52 | 116.88 |
| 2 | 34.71 | 1 | 5.53 |
| 3 | 28.23 | 1 | 9.85 |
| 4 | 45.53 | 1 | 5.13 |
| 5 | 426.93 | 10 | 112.39 |
| 6 | 1,446.46 | 21 | 373.2 |
| 7 | 33.86 | 1 | 10.77 |
| 8 | 854.5 | 10 | 334.37 |
| 9 | 145.91 | 3 | 68.93 |
| 10 | 665.51 | 53 | 274.86 |
| 11 | 98.36 | 1 | 5.49 |
| 12 | 5.76 | 1 | 5.54 |
| 13 | 33.48 | 1 | 11.93 |
| 14 | 61.27 | 1 | 6.8 |
| 15 | 90.57 | 2 | 20.52 |
| 16 | 37.06 | 1 | 8.79 |
| 17 | 18.03 | 1 | 6.94 |
| 18 | 216.01 | 1 | 75 |
| 19 | 33.8 | 1 | 11 |
| 20 | 18.98 | 1 | 5.99 |
| 21 | 36.63 | 2 | 11.07 |
| 22 | 14.07 | 1 | 5.43 |
| 23 | 13.82 | 1 | 5.07 |
| 24 | 31.41 | 1 | 6.47 |
| 25 | 37.61 | 1 | 7.41 |
| 26 | 17.75 | 1 | 5.71 |

Total Number of Grassland Networks = 26
Total Area of Grassland Networks = 5765.08ha
Total number of Grassland Core Areas =171
Total area of Grassland priority (home) habitat = 1934.38ha
Total area of Grassland Core Areas =1511.07ha*

**Woodland Networks**

| Network ID | Network Area (Ha) | Core area Count | Core area Area (Ha) |
|---|---|---|---|
| 1 | 254.89 | 2 | 36.35 |
| 2 | 306.45 | 8 | 155.66 |
| 3 | 1,493.37 | 15 | 342.91 |
| 4 | 163.08 | 1 | 36.66 |
| 5 | 763.74 | 4 | 120.27 |
| 6 | 282.33 | 1 | 41.22 |
| 7 | 239.88 | 2 | 20.08 |
| 8 | 233.31 | 5 | 34.54 |
| 9 | 293.09 | 2 | 62.9 |
| 10 | 134.51 | 1 | 31.92 |

Total Number of Woodland Networks = 10
Total Area of Woodland Networks = 4164.65ha
Total number of Woodland Core Areas =41
Total area of Woodland priority (home) habitat = 2752.13ha
Total area of Woodland Core Areas =882.51ha*

**Heathland and Acid Grassland (HAG) Networks**

| Network ID | Network Area (Ha) | Core area Count | Core area Area (Ha) |
|---|---|---|---|
| 1 | 417.65 | 1 | 163.98 |
| 2 | 93.75 | 1 | 23.42 |

Total Number of HAG Networks = 2
Total Area of HAG Networks = 511.4ha
Total number of HAG Core Areas =2
Total area of HAG priority (home) habitat = 98.03ha
Total area of HAG Core Areas =187.4ha*

** Core areas are included in the areas of home habitat but are listed separately because they are of sufficient size to support viable populations of the relevant generic focal species*

# 7. Restoration of Ecological Networks

## Introduction

7.1 Policy SMP5 in the Minerals Local Plan supports the restoration of ecological networks. 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[14]. The Somerset LNP[15] is looking *to '…develop innovative ways of engaging new sectors in work to benefit nature and ecological networks.'* It might also involve a locally determined Nature Improvement Area for Mendip although this is still in the consultation phase.

## Restoration Areas

7.2 Restoration areas are designed to enhance connectivity, resilience and functioning of the ecological network.

7.3 Opportunities for building the resilience of ecological networks are numerous. It will be critical to ensure that no further priority habitat is lost and that the quality of existing habitat is maintained or enhanced. Restoration areas can occur within individual networks or between them:

7.4 Options for restoration areas within individual networks:

- Increasing the size of core areas;
- Increasing the quality of habitat within core areas;
- Creating buffers around core areas. For example around a core area an area of targeted land use that does not adversely affect the habitat of the core area or to mitigate damaging effects from intensive land use;
- Increasing structural connectivity between stepping stones (such that they may eventually form further core areas) or function as a core area for discrete metapopulations for certain species;

[14] http://www.defra.gov.uk/environment/natural/whitepaper/local-nature-partnerships/
[15] http://www.somersetwildlife.org/local_nature_partnership.html

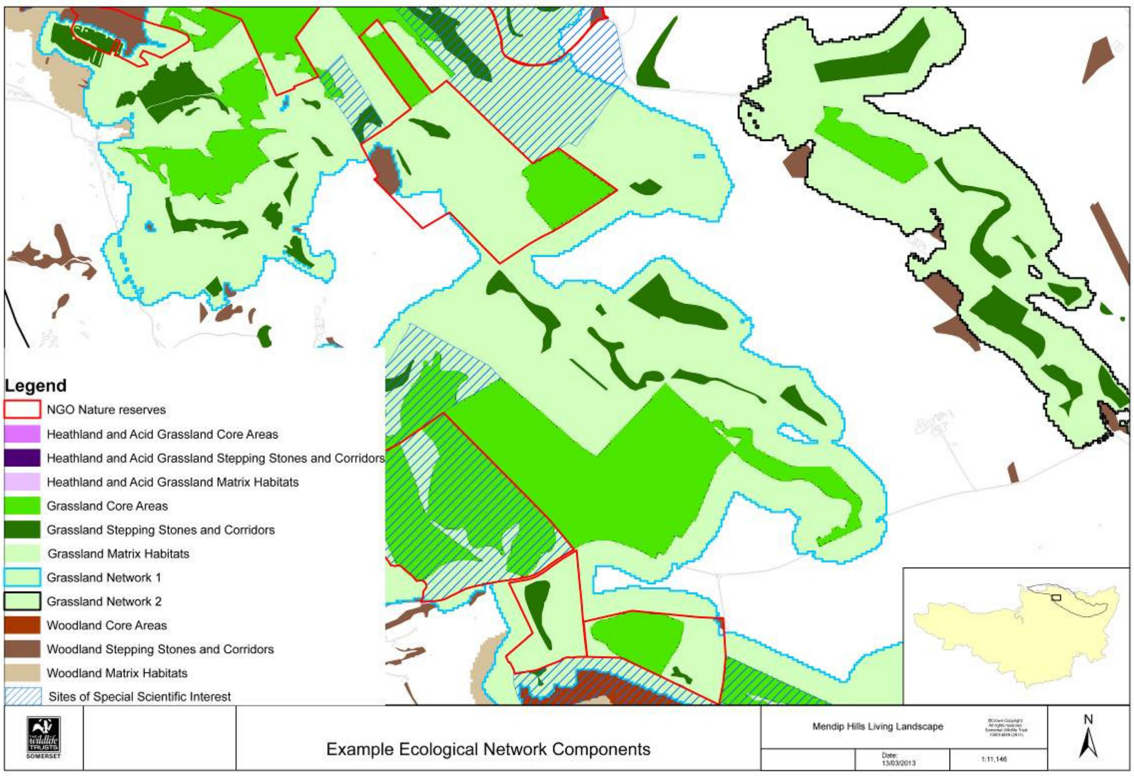
- Improving the permeability (functional connectivity) of the matrix habitat;
- Creating new habitat that can act as stepping stones or corridors: and

7.5 Between separate networks:

- Ensuring that remaining fragments of priority habitat are safeguarded where possible;
- Increasing the size or number of stepping stones or corridors between networks with the aim of improving structural connectivity between networks; and
- Improving the permeability (functional connectivity) of the areas between key networks (sustainable use)

7.6 Restoration Areas will be selected based on a number of factors including their size, proximity to existing features on the network, the condition of the habitat, the likelihood of restoration being successful, and future surrounding land use and landowner.

**Figure 5: Detail of grassland ecological networks showing individual networks and their components**



## Sustainable Use Areas

7.7 Lawton *et al* (2010) defines sustainable use 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 (Bennett and Mulongoy 2006). Set up appropriately, they help to 'soften the matrix' outside the network and make it more permeable and less hostile to wildlife, including self- sustaining populations of species that are dependent upon, or at least tolerant of, certain forms of agriculture. There is overlap in the functions of buffer zones and sustainable use areas, but the latter are less clearly demarcated than buffers, with a greater variety of land uses.*'

7.8 Sustainable use comprises the majority of the landscape. The aim is to improve the permeability of the land surrounding the discrete ecological networks. This could be through agri-environment scheme options that can be tailored to suit local conditions and promote management of farmland that is environmentally sensitive.

## 8. Review and Monitoring

8.1 Maps of the ecological networks can be obtained from the Somerset County Council website.[16]

8.2 Species and habitat data will be updated periodically and the Mendip Hills Ecological Network will be subject to review. For example new information from surveys could also result in correcting and/or remodeling ecological networks. This could include identifying new Core Areas which do not currently fulfill the criteria for selection. Such changes may have resulted from changes in management or other development.

8.3 In any case it is planned that a review of such changes will be carried out annually by Somerset County Council, the Somerset Wildlife Trust and Somerset Environmental Records Centre.

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16 http://www.somerset.gov.uk/irj/public/services/directory/service?rid=/wpccontent/Sites/SCC/Web%20Pages/Services/Services/Environment/Ecological%20networks

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# APPENDICES

## Appendix 1: Priority 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 such as monkey orchid *Orchis simia*, hoary rockrose *Helianthemum canum* and pasque flower *Pulsatilla vulgaris*. 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.

**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 Mendips Hills Ecological Network Habitats**

The following table gives the habitat descriptions used by the UK BAP and the habitat types used in mapping the Mendip Hills Ecological Network.

| Broad Habitats present in the SW | Priority Habitat Types present in the SW | Mendip Hills Ecological Network habitat |
|---|---|---|
| Broadleaved, mixed and yew woodland | Lowland mixed woodland<br>Lowland beech and yew woods<br>Lowland wood pasture and parkland<br>Upland oak woodland | Broadleaved Woodland |
| Boundary and linear | Ancient or species-rich | Not used |
| Arable and horticulture | Cereal field margins | Not used |
| Improved grassland | Coastal & floodplain grazing marsh | Not used |
| Neutral grassland | Lowland meadows | Priority Grassland |
| | | Priority Grassland |

| Broad Habitats present in the SW | Priority Habitat Types present in the SW | Mendip Hills Ecological Network habitat |
|---|---|---|
| Calcareous grassland | Lowland calcareous grassland | |
| Acid grassland | Lowland dry acid grassland | Priority Grassland<br>Heathland and Acid grassland |
| Bracken | Not a Priority Habitat | Not used |
| Dwarf shrub heath | Lowland heath<br>Upland heath | Heathland and Acid Grassland |
| Fen, marsh and swamp | Fens<br>Purple moor grass & rush pasture | Not used |
| Bogs | Blanket bog | Not used |
| Standing open water & canals | Standing water | Not used |
| Rivers and streams | Rivers and streams | Rivers and Streams |
| Inland rock | Inland cliff and rock | Not used |
| Supralittoral rock | Maritime cliff and slope | Not used |
| Supralittoral sediment | Coastal sand dunes<br>Coastal vegetated shingle | Not used |
| Built-up areas & gardens | Not a Priority Habitat | Not used |

# Appendix 2: Information Informing the Development of Generic Focal Species

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 the Mendip Hills but have been recorded in Somerset as a geographic area. This will enable consistency of approach with the Somerset-wide ecological network, the Somerset Econet. Those species that occur in the Mendip Hills are noted in bold type in the appendices on species.

The following sections set out the metrics for each of the type of habitat the metrics used in modelling the network.

## Broadleaved Woodland Species

The woodland habitat used for the Mendip Hills Ecological Network includes all OS Mastermap polygons designed with the Integrated Habitat System (IHS) codes beginning WB.

A list of woodland specialists occurring within the Somerset Priority Species List can be found in Appendix 3.

**Patch Size**

Woodland mammal species on the list include the common or hazel dormouse and four bat species, the lesser horseshoe, brown long-eared, Brandt's and Bechstein's bats. The minimum area considered to sustain a common dormouse population is considered to be 20 hectares within a connected network of hedgerows, copses and woodland (Bright *et al*, 1996).

The area of woodland for the bat species with the exception of Bechstein's bats is less important as it is considered this would be part of a mosaic of wooded habitat including hedgerows within the home range of each species. Colonies of Bechstein's bats generally are more restricted to the home woodland. 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). The minimum area to support a maternity colony is considered to be 25 hectares of woodland for the purposes of the Bechstein's bat survey carried out by the Bat Conservation Trust in 2009 to 2011 (Miller, 2011).

Woodland bird species on the Priority Species List include wood warbler, willow tit and marsh tit. Populations of both breeding wood warbler and willow tit are likely to use several woodlands. Wood warbler is a summer migrant to Britain (Holden & Cleeves, 2002) whilst willow tits are resident and considered highly sedentary they can natally disperse over distances of 5 kilometres[17]. The marsh tit requires woodland of 25 hectares in area before breeding (Hinsley *et al*, 1994).

A number of specialist woodland moth and butterfly species occur in Somerset. These are listed in Appendix 3. Minimum woodland patch sizes to support populations are unknown but are likely to be less than area requirements for mammals or birds.  The area required for other invertebrate species are also Not sourced but are likely to be smaller that vertebrate species.

The results of a study in the Netherlands of the effects of habitat fragmentation on woodland flora by Grashof-Bokdam (2009) showed that the number of species of all categories increased with area. The occurrence of ten individually studied species was also positively related to area. Most of them were interior species. The minimal area for interior species in which they were present was 0.2 hectares.

Based on consideration of woodland patch sizes required to support viable populations the minimum size of woodland used in the BEETLE model for a Generic Focal Species for woodland is 20 hectares. This would include woodland patches likely to support a population of the common dormouse which is a species listed on Annex IV of the Habitats Directive.

[17] http://www.gmbp.org.uk/site/images/stories/willow%20tit%20bap_09.pdf

Core Areas are defined as woodland habitat of at least 20 hectares.

**Dispersal Distance**

The dispersal distances for the woodland bat species are can be many kilometres between summer and winter roosting sites. During activity periods all species are reliant on structural connectivity between resting and feeding areas. The ability to move around the landscape for these species is determined by the presence of suitably structured habitat, such as mature unmanaged hedgerows. These structures are usually associated with smaller field sizes and pasture. From a consideration of structural connectivity in the Mendip Hills and radio tracking data from surveys undertaken by Billington (2000) of greater horseshoe bats a proxy distance of about 250 metres can be said to be the distance from woodland where such connectivity is likely to exist.

The common dormouse is capable of crossing matrix habitats between woodland blocks. A male dormouse may disperse up to 1600 metres from its natal habitat (Bright & Morris, 2008). Dormice 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).

The wood warbler is a summer migrant to Britain and willow tits can disperse distances over 5 kilometres. The natal dispersal distance for marsh tits was up to 2 kilometres with a median distance of 3.1 territory widths for females (1065 metres). The maximum dispersal distance was found to be 7 kilometres. However, they have limited ability to cross matrix habitats with the largest gap in interconnecting hedgerows of 256.2 metres. (Broughton *et al*, 2010)

Butterfly and moth dispersal distances vary between species. 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). Based on this study oak hook-tip may disperse about 1150 metres, flounced chestnut and oak lutestring moths may disperse 1000 metres, and drab looper about 350 metres. The wood white butterfly has been recorded dispersing up to 4 kilometres and the white admiral over quite large distances (Asher *et al*, 2001).

Other invertebrates have varying dispersal capabilities. *Brachypalpus laphriformis*, *Meligramma guttatum*, *Myolepta dubia* and *Xylota abiens*, woodland hoverfly species are likely to be capable of dispersing about 3 kilometres based on a study of a hoverfly species in Scotland[18]. Cranefly populations are separated by distances of about 250 metres (Freeman, 1964). *Ctenophora flaveolata* and *Lipsothrix nervosa* are woodland cranefly species listed in the Somerset Priority List. The dispersal distance of gnats varies enormously from several kilometres to a few hundred metres (Capinera, 2008; Mellor *et al*, 2010). In one study midges reached areas over 3 kilometres from a lake, but more than 90% of the midges flew within 500 metres of the lake's shoreline (Hirabayashi, 1991). *Brachypeza armata* and *Neoempheria striata*, woodland fungus gnat species, are likely to disperse lesser distances within the woodland. Soldier flies are weak fliers[19].

Flora species are dependent on a number of dispersal mechanisms. There are a number of fungi species associated with woodland listed on the Somerset Priority Species List (see Appendix 3). Fungal spore dispersal downwind to distance of about 100 metres is easily demonstrable (Carlile *et al*, 2001). Many lichens break up into fragments when they dry, dispersing themselves by wind action, to resume growth when moisture returns. Humphrey *et al* (2008) give the maximum dispersal distance for a broadleaved woodland lichen species (*Pseudocyphellaria Norvegica*) as 50 metres. However, some specialist woodland lichens can re-colonise but need old growth trees within 2.5 kilometres (Woodland Trust, 2000).

Specialist woodland vascular plants on the Somerset Priority Species List include white helleborine; narrow-lipped helleborine; yellow bird`s-nest; bird's-nest orchid; greater butterfly-orchid and whitebeam species. Helleborines and orchids have minute spores, whereas whitebeam species are dispersed through digestion by animals. Yellow bird's-nest lives off of decaying vegetable matter and its fruit a capsule is likely to be dispersed short distances dispersed by the wind. (Blamey *et al*, 2003; Hermy *et al*, 1999)

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[18]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

[19] http://entomology.cornell.edu/cals/entomology/extension/vet/upload/Common_pest_fly_factsheet.pdf

Animal dispersed flora species are expected to have a low mean dispersal distance because woodland animal dispersers (mainly birds and ants) have small home ranges which are limited to the configuration of the woodland. The number of species dispersed by animals goes up with increasing connectivity but this is limited to patches within about 100 metres. Interior species are also expected to be affected by isolation. (Grashof-Bokdam, 2009) A dispersal distance of about 700 metres through defecation is given by Greene & Calogerpolous (2002).

'*For many woodland invertebrate species* [and presumably flora], *local scale processes are potentially more important than processes operating at the landscape scale in terms of species persistence, especially for those species that show high dependence on woodland habitat conditions and have limited dispersal ability*' (Brouwers, 2008). There may be some genetic variations in invertebrate populations that if connected would then lose the variation present in the population, such as has been found with wood crickets on the Isle of White (Dr Kevin Watts, Forest Research, pers. comm.). Therefore the selection of a too short of dispersal distance may not be suitable in modelling a woodland network.

Therefore, based on consideration of the above it is considered that 800 metres is applied to the model to represent dispersal distances for woodland species. This is within the range of the maximum dispersal distance for common dormice and also represents distances recorded elsewhere for other woodland species. The distance would also be representative of distances within the capability of longer ranging moth and butterfly species. Given that permeability scores are also applied the distance should also provide a proxy for those species more reliant on structural connectivity.

## Priority Grassland Species

Calcareous, acid and neutral grassland habitat used for the Ecological Network includes all OS Mastermap polygons designated with the Integrated Habitat System (IHS) codes beginning GA, GC and GN.

A list of priority grassland specialists occurring within the Somerset Priority Species List can be found in Appendix 4.

### Patch Size

The skylark is a bird of open grassland, including meadows, farmland, commons and sand dunes. The nest is always placed in a hollow in the ground and often partly concealed with a tussock of grass. They can also nest amongst crops. They feed entirely on the ground on both plant matter and invertebrates. (Gillings & Fuller, 2001) 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[20])

The Somerset Priority Species List includes a number of invertebrate and flora species regarded as calcareous and / or neutral grassland specialists.

There are a number of butterfly and moth species associated with calcareous grassland. Wilson *et al*, 2002 considered that the brown argus butterfly needed very wide areas for the protection or management of habitat in order to avoid extinctions or even networks of patches. 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. Patches of about 5 hectares were generally occupied by brown argus butterflies. (Wilson *et al*, 2002)

Population densities of adult chalk-hill blue butterflies ranged from 0.04 to 0.32 individuals per $m^2$ and were not significantly affected by habitat area or the horseshoe vetch population size but increased with increasing habitat connectivity (Brückmann *et al*, 2011). Otherwise the minimum are required to support a population has not been sourced.

In a study by Krauss *et al* (2004a) of small blue butterflies the minimum area in which they were found was 0.04 hectares. However the larger the area of the host plant the greater the population of small blue were present. The isolated and small populations of the butterfly were considered to be prone to extinction, but the dispersal ability of the small blue seemed high enough to allow regular re-immigrations from large source populations to rescue sink populations. This was supported by the fact that eggs, but not adults, were found even at isolated, small habitats with few kidney vetch plants. (Krauss *et al*, 2004a)

Large blue butterflies have discrete colonies on small patches (typically 2-5 hectares) from which adults rarely stray (Asher *et al*, 2001). Colonies tend to be small, typically less than 20 adults, but can be up to 70 butterflies, distributed over an area of several hectares. Population densities normally vary between 2 - 10 butterflies per hectare,

[20] http://www.earthplatform.com/british/bird/database

but can be as high as 50 per hectare where conditions are ideal[21]. The largest populations contained about 1000 adult butterflies per hectare[22].

Marsh fritillaries are associated with grassland where devil's bit scabious grows. They require 70 hectares of suitable habitat to sustain populations in the long term. They occurred at 20 individuals per 0.92 hectares in Belgium. Marsh fritillary butterflies are likely to function as metapopulations as described in Hanksi (1999) and connectivity is an important factor in explaining habitat occupancy (Borsje, 2005)

Krauss *et al* (2004b) studied the effect of habitat loss and fragmentation on plant species in calcareous grassland in Germany. It was found that plant species numbers increased significantly with increasing habitat area for both habitat specialist and habitat generalist plant species, while habitat isolation or landscape diversity did not have significant effects. Specialist plant species are not more affected by reduced habitat area than generalists.

Based on consideration of unimproved grassland patch sizes required to support viable populations the minimum size of patch of a Generic Focal Species for unimproved grassland used in the BEETLE model is 5 hectares. Five hectares is likely to support a population of large blue butterflies, which are listed on Annex IV of the Habitats Directive. At 5 hectares populations of over 300 individuals of small blue butterflies might be expected if kidney vetch is present in the sward (Krauss *et al*, 2004a)

Core Areas are defined as unimproved grassland habitat of at least 5 hectares.

**Dispersal Distance**

The brown argus is associated with calcareous grassland. 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.

Adult small blue butterflies, another species associated with calcareous grassland, rarely move more than 40 metres. However, some longer movements have been

[21] http://www.learnaboutbutterflies.com/Britain%20-%20Maculinea%20arion.htm
[22] http://ec.europa.eu/environment/integration/research/newsalert/pdf/163na1.pdf

recorded, including a few of over 1 kilometre between neighbouring sites and vagrants have been recorded in Wiltshire as far as 17 kilometres from known colonies. (Asher *et al*, 2001; Fuller, 1995; http://www.butterfly-conservation.org/uploads/sb_action_plan.pdf) Krauss *et al* (2004a) found the eggs of small blue butterflies or a high number of adults (>7) in all habitats with kidney vetch (which are calcareous grasslands) even when isolated up to 2–4 km.

The dingy skipper is regarded as being sedentary (Asher *et al*, 2001). However, no information on dispersal range for the species has been sourced.

The re-introduced large blue butterfly have some dispersal capability and have been found in new colonies 2 - 3 kilometres away, covering numerous small patches of calcareous grassland (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)

The average dispersal distance of moths has been shown to be related to the species wing span (Dulieu *et al*, 2007). Based on this study gallium carpet moth may disperse about 700 metres, the chalk carpet moth about 800 metres and the lunar yellow underwing moth may disperse 1200 metres.

The dispersal capabilities of other calcareous grassland invertebrates vary. *Pelecopsis radicicola* is a money spider found in calcareous grasslands. Money spiders have low dispersal distances due to low wind velocities present additional complications for successful colonisation (Bonte *et al*, 2003). Crab spider dispersal is likely to be likewise limited. There are two priority hoverflies associated with calcareous grassland, *Cheilosia cynocephali* and the phantom hoverfly, *Doros profuges*. These are likely to be capable of dispersing about 3 kilometres based on a study of a hoverfly species in Scotland[23]. The shrill carder bee, found mainly in neutral grasslands, was found to have a minimum mean foraging distances calculated at 231 ± 58 metres (Connop *et al*, 2011)

Flora species are dependent on a number of dispersal mechanisms. There are three *Hygrocybe (*waxcap) species associated with calcareous grassland and one with neutral grassland, the pink waxcap, listed on the Somerset Priority Species List (see Appendix 4). Fungal spore dispersal downwind to distance of about 100 metres is

[23]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

easily demonstrable (Carlile *et al*, 2001) and probably more in open calcareous habitats. *Cephaloziella calyculata* is a liverwort species found in calcareous grassland listed on the Priority List. Liverworts spores are dispersed by the wind[24].

Vascular plants listed on the Somerset Priority Species List occurring in calcareous grassland habitat include dwarf mouse-ear, frog orchid, slender bedstraw, early gentian, white rock-rose, Somerset hair-grass and honewort. Green-winged orchids are associated with neutral grassland. Most are unlikely to disperse more than 150 metres and probably a lot less on the wind. Those using adhesion to animal fur, such as bedstraw, may reach 300 metres. (Greene & Calogerpolous, 2002)

Therefore, based on consideration of the above it is considered that 700 metres is applied to the model to represent dispersal distances for calcareous grassland species. This is within the range of most butterfly and moth priority species. Although the maximum dispersal distance for brown argus is about 900 metres most disperse less than 500 metres (Wilson & Thomas, 2002). However, assuming that the species is capable of dispersing 300 metres over intervening farmland it is considered that 700 metres would be appropriate for this species as well given that farmland is considered 'hostile habitat' for the species and that the appropriate permeability scores would be applied.

## Heathland and Acid Grassland Species

The heathland and acid grassland habitat used for the Ecological Network includes all OS Mastermap polygons designated with the Integrated Habitat System (IHS) codes beginning HE and GA.

A list of heathland and / or acid grassland specialists occurring within the Somerset Priority Species List can be found in Appendix 5.

### Patch Size

Nightjar and Dartford warbler are bird species from the Priority Species List associated with heathland habitat. For nightjars the average size of an occupied patch of heathland is 106 hectares (Bright *et al*, 2007). The minimum size of occupied patches of clear felled woodland was 5 hectares with a mean size of 23 hectares. Nightjar territories were frequently centred on a large woodland clearing

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[24] http://science.jrank.org/pages/3968/Liverwort-Spore-dispersal.html

with an area of at least 0.7 ha. Clearings less than 50 metres wide were not colonized. (Cresswell, 1996; Cramp, 1985; Wichmann, 2004) In Dorset the minimum size of an occupied path was 0.2 hectares and the minimum size occupied by more than one breeding pair was 1.5 hectares (Bright *et al*, 2007).

The territory size for Dartford warblers is about 2 to 3 hectares (Shirihai *et al*, 2010). Therefore it is considered that a sustainable population of Dartford warbler's would require about 75 hectares of heathland within the species dispersal capabilities using the method developed by Allen *et al*, 2001 for minimum viable areas for vertebrates.

An isolated and inbred population of adders has survived on the Swedish coast in an area of approximately 1 kilometre by 50 to 250 metres wide (approximately 12.5 ha) (Madsen & Ujvari, 2011). 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) or at about a density of 4 per hectare (Langton & Beckett, 1995). In Dorset populations of 73 and 52 adults are supported in areas of 50 and 35 hectares respectively (Phelps, 2004), which is less than 1 snake per hectare. A population of >20 is considered exceptional (Langton & Beckett, 1995).

There are a number of moth and butterfly species associated with heathland on the Somerset Priority Species List. The heath fritillary is confined to areas to Exmoor. The heath fritillary can breed in areas of less than 2 hectares of suitable habitat (Warren, 1997). A minimum area of 5 hectares is used for woodland reintroductions in Kent (Holloway *et al*, 2003). Moth species include Haworth's minor, broom-tip, dingy mocha, argent and sable, the anomalous, heath rustic and neglected rustic. Minimum heathland patch size to support populations of these species is unknown but is likely to be less than area requirements for mammals or birds and similar to that of the heath fritillary. The area required for other invertebrate species are also Not sourced but are likely to be smaller that vertebrate species.

A number of heathland flora species is listed in the Somerset Priority Species List. These include common or lesser dodder, *Euphrasia anglica* (a brighteye), common cudweed, petty whin, heath dog-violet and pale dog-violet. Common chamomile is found on grazed acidic soils.

Fragmentation has an important effect on the species richness of heathlands. There is a positive plant diversity-area relationship for the heathland patches in the Flanders region. This positive species-area relationship is not caused by higher habitat heterogeneity in larger fragments, but probably because the patches are quite monotonic as far as abiotic conditions are concerned. The effect of isolation seemed to be most important. '*The limited effects of patch area on the heathland plant community indicate that even small patches can contain a diverse and species rich heathland plant community*.' (Piessens, 2006)

Based on consideration of heathland and acid grassland patch sizes required to support viable populations the minimum size of patch of a Generic Focal Species for heathland used in the BEETLE model is 20 hectares. Twenty hectares is likely to be occupied by nightjars and would support more than one territory of breeding Dartford warblers within a network of such habitat, both of which are listed on Schedule 1 of the Wildlife and Countryside Act 1981. Although adders are likely to require 30 hectares or more of heathland / acid grassland they can be found on rough commons, in disused quarries, partially felled or young conifer woodland and open broadleaved woodland (usually where it occurs next to any of the other aforementioned habitats or along rides) [Beebee & Griffiths, 2000].

Core Areas are defined as heathland and / or acid grassland habitat of at least 20 hectares.

**Dispersal Distance**

Although nightjars are migratory birds it was found that density increased with increasing connectivity to other patches, particularly occupied patches. Overall, 40% of the occupied heathland patches were less than 100 metres, and 86% less than 500 metres, from the nearest other occupied patch. (Bright *et al*, 2007)

Adult Dartford warblers are faithful to their territories and move at most 4.5 kilometres whereas juveniles disperse up to 6 kilometres from their place of birth in England (Shirihai *et al*, 2010).

Adders migrate 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) One study recorded two young adders in outlying areas between 2 and 3 kilometres away from their place of birth (Phelps, 2004)

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 kilometres. (Warren, 1987a; Asher *et al*, 2001)

The average dispersal distance of moths has been shown to be related to the species wing span (Dulieu *et al*, 2007). Based on this study Haworth's minor moth may disperse about 620 metres, the broom-tip about 680 metres, the dingy mocha about 570 metres, argent and sable about 960 metres, the anomalous 800 metres, the heath rustic 775 metres and the neglected rustic moth may disperse 1100 metres.

Of the other heathland invertebrate priority species *Aphrophora alpine*, a frog hopper, is likely to have a maximum dispersal range of about 600 metres (Biedermann, 2000). Other species have shorter dispersal ranges; *Scleroracus decumanus*, a leaf hopper is likely to be capable of dispersing about 100 metres[25] and the erratic ant about 200 metres[26]. Another leaf hopper *Macrosteles quadripunctulatus*, found on inland acid grassland is likely to have similar dispersal capabilities.

Vascular plants listed on the Somerset Priority Species List occurring in heathland habitat include common or lesser dodder, *Euphrasia anglica* (an eyebright), common cudweed, petty whin, heath dog-violet and pale dog-violet. Dodder is a parasitic plant which is most likely to be dispersed through attachment to an animal. This may reach 300 metres away from the parent stock. Most are unlikely to disperse more than 150 metres and probably a lot less on the wind. (Greene & Calogerpolous, 2002) *Calluna vulgaris* and *Erica cinerea*, the dominant species of heathland, dispersal has been recorded at 80 metres from source plants (Bullock *et al*, 2002).

Therefore, based on consideration of the above it is considered that 500 metres is applied to the model to represent dispersal distances for heathland species. This is

[25] http://www.jcronin.biology.lsu.edu/biograph/publications/Planthopper%20movement%202003.pdf
[26] http://en.wikipedia.org/wiki/Erratic_ant; http://jncc.defra.gov.uk/_speciespages/2642.pdf

within the range of breeding bird species and where occupation be nightjars between patches would be expected (Bright *et al*, 2007). It is also within the dispersal capabilities of heath fritillary and all the estimated distances for heathland moth species.

## Summary of Generic Focal Species Metrics

| Habitat Type | Patch Size (hectares) | Dispersal Distance (metres) |
|---|---|---|
| Broadleaved Woodland | 20 | 800 |
| Unimproved Grassland | 5 | 700 |
| Heathland and Acid Grassland | 20 | 500 |

# Appendix 3: Woodland Species from the Somerset Priority Species List

Species recorded in the Mendip Hills are highlighted in bold text.

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (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.<br>If the host colony moves its nest, or establishes new nests, the guest ant moves with it.<br>http://www.arkive.org/shining-guest-ant/formicoxenus-nitidulus/#text=Biology | 25? | Not sourced | ? |
| 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. Inter territorial 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<br>http://thule.oulu.fi/vaccia/reports/Vaccia_ACT11_deli1_2011.pdf<br>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. | 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 (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| | | | http://www.gmbp.org.uk/site/images/stories/willow%20tit%20bap_09.pdf | | | |
| 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 |
| 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 | Not sourced | 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 | Not sourced | 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 | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| 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 | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| Butterflies & Moths (Lepidoptera) | Sciota hostilis | A micro-moth | Fuentes-Montemayor *et al*, 2012 | 200 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| Fungi | Boletus torosus | A bolete fungus | Carlile *et al*, 2007 | 200 | Not sourced | ? |
| Fungi | Cantharellus friesii | A fungus | Carlile *et al*, 2007 | 200 | Not sourced | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| Fungi | Cantharellus melanoxeros | A fungus | Carlile *et al*, 2007 | 200 | Not sourced | ? |
| Fungi | Chlorencoelia versiformis | A fungus | Carlile *et al*, 2007 | 200 | Not sourced | ? |
| Fungi | Cotylidia pannosa | A polypore fungus | Carlile *et al*, 2007 | 200 | Not sourced | ? |
| Fungi | Hydnellum concrescens | Zoned Tooth | Carlile *et al*, 2007 | 200 | Not sourced | ? |
| Fungi | Hydnellum spongiosipes | Velvet Tooth | Carlile *et al*, 2007 | 200 | Not sourced | ? |
| Fungi | **Hygrocybe ceracea** | **Butter Waxcap** | Carlile *et al*, 2008 | 200 | Not sourced | ? |
| Fungi | Phellodon confluens | Fused Tooth | Carlile *et al*, 2009 | 200 | Not sourced | ? |
| Fungi | Phylloporus pelletieri | A bolete fungus | Carlile *et al*, 2010 | 200 | Not sourced | ? |
| Fungi | **Piptoporus quercinus** | **Oak Polypore** | Carlile *et al*, 2011 | 200 | Not sourced | ? |
| Hoppers (Homoptera) | Platymetopius undatus | A leafhopper | http://www.jcronin.biology.lsu.edu/biograph/publications/Planthopper%20movement%202003.pdf | 100 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| 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 | Not sourced | ? |
| 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 (JUSKAITIS, R. 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*, 1996). 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 | **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 | 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 (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| | | | connectivity between woodland elements compared to habitat use from radio tracking studies of horseshoe bats (Jones & Billington, 1999; Billington, 2000 ) | | | |
| 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 |
| 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). | 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 | N/A |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| | | | 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.<br><br>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) | | 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. | |
| 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.<br>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 | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| 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 | ? |
| 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 leonina | 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 | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| 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 | ? |
| 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 digestion | ? | 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 | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area (MVA) | MVA (ha) |
|---|---|---|---|---|---|---|
| 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 | ? |
| 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: Priority Grassland Species from the Somerset Priority Species List

Species recorded in the Mendip Hills are highlighted in bold text.

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | MVA (Ha) | Grassland Habitat IHS Code |
|---|---|---|---|---|---|---|---|
| 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 | Not sourced | ? | GN |
| Beetles (Coleoptera) | Meloe rugosus | Rugged Oil Beetle | Oil beetle larvae use bees to disperse http://www.arkive.org/oil-beetle/meloe-proscarabaeus/#habitat | 250 | Not sourced | ? | GN |
| 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) | ? | GN |
| 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 | ? | GN / GC |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | MVA (Ha) | Grassland Habitat IHS Code |
|---|---|---|---|---|---|---|---|
| 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 | GC |
| 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 | ? | GC |
| 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 | ? | GC |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | MVA (Ha) | Grassland Habitat IHS Code |
|---|---|---|---|---|---|---|---|
| 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 | ? | GC |
| 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, 2005] | 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 | GN / GC |
| 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 | GC |
| 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 | ? | GC |
| 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 $m^2$. (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 | ? | GC |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | MVA (Ha) | Grassland Habitat IHS Code |
|---|---|---|---|---|---|---|---|
| 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 | ? | GC |
| Fungi | **Hygrocybe calciphila** | **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) | 200 | Not sourced. Probably exists in metapopulations | ? | GC |
| Fungi | **Hygrocybe calyptriformis var. calyptriformis** | **Pink Waxcap** | Carlile *et al*, 2001; distances assumed | 200 | Not sourced. Probably exists in metapopulations | ? | GN |
| 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 | Not sourced. | ? | GC |
| Fungi | **Hygrocybe virginea var. ochraceopallida** | **A basidiomycete fungus** | Carlile *et al*, 2001; distances assumed | 200 | Not sourced | ? | GC |
| 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 | Not sourced | ? | GC |
| 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 | Not sourced | ? | GC |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | MVA (Ha) | Grassland Habitat IHS Code |
|---|---|---|---|---|---|---|---|
| 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 | Not sourced | ? | GC |
| Spiders | Ozyptila nigrita | A crab spider | Not sourced | ? | Not sourced | ? | GC |
| 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 | Not sourced | ? | GC |
| True Flies (Diptera) | **Cheilosia cynocephala** | **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=76 | 3000 | Not sourced | ? | GC |
| 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 | Not sourced | ? | GC |
| Vascular Plants | **Cerastium pumilum** | **Dwarf Mouse-ear** | 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 | Not sourced | ? | GC |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | MVA (Ha) | Grassland Habitat IHS Code |
|---|---|---|---|---|---|---|---|
| Vascular Plants | **Coeloglossum viride** | **Frog Orchid** | Greene & Calogerpoulos, 2015 | 150 | Not sourced | ? | GC |
| Vascular Plants | **Galium pumilum** | **A bedstraw** | Greene & Calogerpoulos, 2031 | 150 | Not sourced | ? | GC |
| Vascular Plants | Gentianella anglica | Early Gentian | Greene & Calogerpoulos, 2034 | 150 | Not sourced | ? | GC |
| Vascular Plants | **Helianthemum apenninum** | **White Rock-rose** | Greene & Calogerpoulos, 2039 | 150 | Not sourced | ? | GC |
| Vascular Plants | **Koeleria vallesiana** | **Somerset Hair-grass** | Greene & Calogerpoulos, 2049 | 150 | Not sourced | ? | GC |
| Vascular Plants | **Orchis morio** | **Green-winged Orchid** | Greene & Calogerpoulos, 2049 | 150 | Not sourced | ? | GN |
| Vascular Plants | **Trinia glauca** | **Honewort** | Greene & Calogerpoulos, 2115 | 150 | Not sourced | ? | GC |

# Appendix 5: Heathland and Acid Grassland Species from the Somerset Priority Species List

Species recorded in the Mendip Hills are highlighted in bold text.

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | 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 | Not sourced | ? |
| 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).<br><br>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 | Not sourced | ? |
| 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<br>. | 680 | Not sourced | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | MVA (ha) |
|---|---|---|---|---|---|---|
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| 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 | Not sourced | ? |
| Hoppers (Homoptera) | Aphrophora alpina | A froghopper | Mean distance between occupied patches in a metapopulation of froghoppers was 221.5 +/- 401.3metres (Biedermann, 2000). | 600 | Not sourced | ? |
| Hoppers (Homoptera) | Macrosteles quadripunctulatus | A leafhopper | Biedemann (2000) | 600 | Not sourced | ? |
| Hoppers (Homoptera) | Scleroracus decumanus | A leafhopper | http://www.jcronin.biology.lsu.edu/biograph/publications/Planthopper%20movement%202003.pdf | 100 | Not sourced | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | 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 | Not sourced | ? |
| Mosses | Dicranum spurium | A moss | Wind taken as small seeds = 150 metres ((Greene & Calogeropoulos, 2002) | 150 | Not sourced | ? |
| 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) | Chyliza extenuate | A fly | Not sourced | ? | Not sourced | ? |
| True Flies (Diptera) | Pelecocera tricincta | A hoverfly | Assumed: http://www.sbes.stir.ac.uk/conservation_conference/documents/ERotheray.pdf | 3000 | Not sourced | ? |
| 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 | Not sourced | ? |
| Vascular Plants | Cuscuta epithymum | Common or Lesser Dodder | Parasite | 150 | Not sourced | ? |

| Taxonomic group | Species (Scientific name) | Species (Common name) | Dispersal Range Source | Dispersal Range (metres) | Minimum Viable Area | MVA (ha) |
|---|---|---|---|---|---|---|
| Vascular Plants | Euphrasia anglica | An eyebright | Greene. & Calogerpoulos, 2002 | 150 | Not sourced | ? |
| Vascular Plants | **Filago vulgaris** | **Common Cudweed** | Greene & Calogerpoulos, 2025 | 150 | Not sourced | ? |
| Vascular Plants | Genista anglica | Petty Whin | Greene & Calogerpoulos, 2033 | 150 | Not sourced | ? |
| Vascular Plants | Viola canina subsp. Canina | Heath Dog-violet | Greene & Calogerpoulos, 2123 | 150 | Not sourced | ? |
| Vascular Plants | **Viola lactea** | **Pale Dog-violet** | Greene & Calogerpoulos, 2124 | 150 | Not sourced | ? |

## Appendix 6: Rivers and Streams Species from the Somerset Priority Species List

Species recorded in the Mendip Hills are highlighted in bold text.

| Species (Scientific name) | Species (Common name) | Dispersal Range Source | Description of Core Area | Core Area Occurs Where There is: | Core Area Length (metres)[27] | 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)<br><br>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. | 1500 | Water body with record of breeding kingfishers in the last 15 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). |

[27] i.e. a length of 1500 metres would be 750 either side of the recorded occurrence but may be adjusted in relation to the record according to local circumstances

| Species (Scientific name) | Species (Common name) | Dispersal Range Source | Description of Core Area | Core Area Occurs Where There is: | Core Area Length (metres)[27] | 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.<br><br>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.<br><br>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).<br>(Broquet *et al*, 2002; Bubb *et al*, 2007) | Presence in watercourse | 3000 | 20 |
| 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/<br>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 | - | - |

| Species (Scientific name) | Species (Common name) | Dispersal Range Source | Description of Core Area | Core Area Occurs Where There is: | Core Area Length (metres)[27] | 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 |
| 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 | Presence in watercourse | 50 | 20 |

| Species (Scientific name) | Species (Common name) | Dispersal Range Source | Description of Core Area | Core Area Occurs Where There is: | Core Area Length (metres)[27] | Period of Record Validity (Years) |
|---|---|---|---|---|---|---|
| | | | area would be the waterfall or cascade with which is associated. Assumed occupancy of 50 metres. | | | |
| Mammal | Arvicola amphibius | Water Vole[28] | 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)<br><br>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 | Presence of colony | 1500 | 10 |

[28] Present in Cheddar town only within the Mendip Hills NCA

| Species (Scientific name) | Species (Common name) | Dispersal Range Source | Description of Core Area | Core Area Occurs Where There is: | Core Area Length (metres)[27] | Period of Record Validity (Years) |
|---|---|---|---|---|---|---|
| | | | viable if not spatially isolated. (Strachan & Moorhouse, 2006) | | | |
| 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 – 200m | Buffer recorded natal holts including watercourses | 400 | 5 (surveyed annually by Somerset Otter Group) |
| 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). | Section of main watercourse mapped for 3 kilometres either side of record. Include known roost sites in core area. This buffered by 8 metres to allow for fringing vegetation (Biron, 2010). | 6000 | 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 | Area of oviposition. Section of main watercourse mapped for 125 metres either side of record. | 250 | 25 |

| Species (Scientific name) | Species (Common name) | Dispersal Range Source | Description of Core Area | Core Area Occurs Where There is: | Core Area Length (metres)[27] | Period of Record Validity (Years) |
|---|---|---|---|---|---|---|
| | | | Occupancy Not sourced therefore assumed Core Area of 50 metres plus 200 metres to allow for recording error. | | | |
| 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 |
| 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_Stonewo | Section of main watercourse mapped for 125 metres either side of record. | 250 | 25 |

| Species (Scientific name) | Species (Common name) | Dispersal Range Source | Description of Core Area | Core Area Occurs Where There is: | Core Area Length (metres)[27] | Period of Record Validity (Years) |
|---|---|---|---|---|---|---|
| | | | rt_Lakeline_Report.pdf The area of occupancy has not been sourced. Assumed spread of 50 metres plus 200 metres for recording error. | | | |
| 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 |
| 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 |