Identifying spatial priorities for Ecological Networks

Chapter 4

A guide to map-based models and tools for planning ecological networks

4.1 - Introduction

The previous sections indicate that there is an urgent need for clear evidence provision to help conservation practitioners design and implement ecological networks. The use of spatial data and tools, to analyse ecological networks in our current landscapes, can provide helpful support when making decisions on how to tackle this task.

However the range and complexity of these resources can soon become confusing. This section aims to help potential users by providing the following:

- Summaries of a range of evidence-based tools, models and data that Natural England has used to assess and/or model ecological networks specifically. This includes; a description of their evidence basis, what they can be used for, how they help to inform conservation decisions, and when it is useful to use them (see section 4.3).

The tools, models and data we present in this chapter are those that help us assess the current or future circumstances or requirements for ecological networks only. This means that wider tools and assessment methods, for example, those that help us assess the landscape character of an area, are not covered here. However, the results of the tools and models we discuss here can be used within such wider frameworks, forming part of the wider knowledge building for a place.

Further appraisal (in greater detail) of a range of spatial models and mapped data is also available in annex 1. There we provide tables that summarise the model or data, including the aims and audience, practical elements such as data and access requirements and a brief assessment of its strengths, weaknesses and overlaps with other models or data.

The input datasets for the tools we describe in this chapter are land-use or habitat- and species-specific. Other knowledge building datasets and tools, covering such areas as landscape quality, recreation assets, demographics and the historic environment as examples, will need to be used alongside these to undertake a fully integrated analysis for a local area (see chapter 3).

This section cannot give definitive answers on which tools to use or how to use available data, or provide an exhaustive list of available ecological network assessment tools and data. However, it does provide what we think are important, useful and relevant tools that can be used in any landscape. Understanding and collating the existing data for a place (Box 1) is an essential first step before deciding to use the models and maps detailed in this chapter.

Important context to consider

Setting the 'Place based' context

Before identifying the tools and data to use, start by identifying the focus of the ecological network and the conservation objectives your ecological network is trying to achieve. For example: do you have a particular species or habitat in mind? (See Chapter 1 & 2). Plus, which multiple benefits, or ecosystem services, are you focussing on? (See Chapter 3). If this is the starting point, it is much more likely that the most appropriate tools or data can be found to help inform ecological network planning. This can be done by gathering existing data, knowledge and experiences alongside gathering the wider datasets and frameworks that help to provide a broad picture of the place, and understand a wider range of objectives. Some data we collect at this early stage will be input into the tools presented here, and some will help set the wider context, including opportunities and constraints. Both are essential.

Setting the wider context can also help identify multifunctional benefits or opportunities to be gained from delivering ecological network enhancement. It may also highlight where proposed benefits for one asset may have a negative impact for another. This may in turn highlight where a more in-depth assessment and discussion of the way forward may be required. Box 1 lists some of the data and evidence that is useful for setting the context for an ecological network in a place. This helps us to think about what we know about a place, its geology, soils, landscape character, topography, and a range of other environmental variables, essential for the spatial design of a network. It also assists with planning a network in the context of a multi-functional landscape, addressing constraints as well as opportunities to deliver multiple benefits.

Box 1: Useful evidence and data sets for understanding your place

Develop your understanding of your area before undertaking any further analysis detailed in this chapter. Many of these data sets may be used as input layers for further analysis and modelling.

- Ordnance Survey base maps
- Soil and geology maps e.g. from the British Geological Society or National Soil Resources Institute
- Topography data e.g. a digital elevation model
- National Character Area profiles (Natural England)
- Landscape Character Assessments
- Land cover maps e.g. Land Cover Map 2015 (Centre for Ecology and Hydrology)
- Habitat maps e.g. Natural England's Priority Habitat Inventory or local phase one habitat surveys
- Species presence and distribution data e.g. National Biodiversity Network Atlas data
- Woodland – from National Forest Inventory (Forest Research)
- Designated sites e.g. Sites of Special Scientific Interest (SSSI), Natura 2000 sites and Ramsar sites
- SSSI condition data (Natural England)
- Environment Agency flood risk maps
- Environment Agency Water Framework Directive status of water bodies
- Scheduled Monuments and Historic Environment Records (Historic England)
- Access, including CROW open access land and public rights of way (Local Authorities)
- Perceived tranquillity maps e.g. from Campaign to Protect Rural England
- Natural England ecosystem services maps (further detail in Annex 1)
- Land management data e.g. location of agri-environment scheme options (Natural England)
- National Character Area Indicators & Thresholds Mapping Tool (further detail in Annex 1)
- Any other maps that you have locally that may supplement the above, National Parks, AONBs, Biological Records Centres and Local Authorities may have useful data.

4.1.2 - Issues to consider

Data quality

The models and data analysis approaches in this chapter are built on identifying all the relevant assets of interest for an area. Habitat and species data provide the foundation for the assessment. Other datasets or evidence are usually then required to analyse the component of the ecological network you are interested in and how it may interact with other factors or interests. This also helps to set the ecological network mapping in the wider landscape context.

The models and tools, and the data they produce, **are only as good as the information they are built on**. When the input information has poor spatial accuracy (scale) or is lacking in information on the habitats and species in the area, the model outputs must be viewed and used with this in mind. This uncertainty might be reduced by cross referencing different data sets, and can be supplemented by ground-truthed data and in-depth local knowledge. In fact local knowledge is essential for interpreting the results of any analysis, as spatial data and the outputs from ecological network models are decision support tools, they don't provide the definitive answer therefore network design has to draw from a range of approaches.

Scale and place

Generally, a combination of national and local datasets will be used to create the underlying baseline input for any model. Scale is very important: there will be outputs that work better for national scale targeting and others that are capable of providing detailed local analysis. However, it is important to understand data at a range of scales and to acknowledge that national coverage does not necessarily mean poor local scale resolution. A number of useful national data sets have a fine resolution, but others may only be useful at a much coarser scale.

The use of tools and data may also be place-specific. Some tools may be relevant in more nature-rich areas such as National Parks, National Nature Reserves or other protected areas. Others are more useful in an urban setting. However, wildlife rich habitats can occur anywhere in the rural to urban continuum. Urban-rural linkages are very important for ecological networks. Bringing nature in to the areas where people live, and allowing it to pass through potential barriers will be key objectives.

Complexity vs. simplicity

A very complex model might not always give a better result; sometimes an indication of the situation is good enough to aid spatial planning. Delving deeply into complicated frameworks or models might not be as useful as gaining a common understanding and overview agreement on the assets within an area. Using four or five key sources of information might be a good place to start, rather than using 20-30 different datasets or a complex model. Complex models often have the added disadvantage of requiring more complex data, more time consuming analysis and specialist skill sets by the user. In addition, as tools increase in complexity, the transparency of how they work decreases and the underlying assumptions are likely to increase. This can result in masking uncertainty in the model results. It is worth stating again that the quality of the input data will affect the model results, no matter how complex the model is.

Uncertainty and action

There are a wide range of factors that influence the creation and enhancement of ecological networks. As such, there is a need to be aware that there are many complex interactions to take into account and the future is, of course, uncertain. The natural environment is highly complex and it will always be impossible to consider or predict everything. At some point modelling and analysis of the problem needs to move to practical action on the ground. In future years learning and understanding can be used to adjust and adapt any approach, this is known as the adaptive management approach (see the Climate Change Adaptation Manual for more information).

There is also a specific need to consider range-expanding and contracting species, current levels of habitat fragmentation and condition as well as changing ecosystem processes. Many models won't cope with this complexity or dynamism. It is important to remember that the tools we present here will usually only provide a snapshot in time and not a complete picture or solution for your area or landscape.

4.2. - Background to map-based models and tools

Models and tools can be viewed on a spectrum from simple to complex. The simpler ones set out basic principles and questions to consider, or help identify problems (e.g. simple vulnerability assessment). More complex ones take connectivity and meta-population approaches. Others assess possible solutions and identify specific areas for action (e.g. conservation prioritisation software such as Marxan). Natural capital tools with an ecosystem focus can provide information on attributes or environmental variables, such as soil characteristics, useful in the design of ecological networks, which are beneficial for both wildlife and people. We will provide information on some of each; the following table gives a brief introduction to some of the tools we will cover:

Table 1: A brief introduction to ecological network tools and their benefits (these are reviewed in more detail below and in Annex 1)

Principle being addressed	Model/ Data	Key benefits	Availability
Climate change adaptation	National Habitat Networks Maps (2018)	National level Habitat Network Mapping for England. Highlights key areas to create and restore habitats and reduce fragmentation.	Data is available as separate habitat networks for many priority habitats or as an integrated product. Available on an open licence.
	National Biodiversity Climate Change Vulnerability Assessment (NBCCVA)	National scale habitat vulnerability analysis.	Available on an open licence.
	Climate change refugia maps	Unique dataset considering location of climate change refugia nationally.	Available on an open licence.
	Species Risks and Opportunities maps	Large number of national climate envelope models available.	Available on an open licence.
Connectivity/ fragmentation	National Habitat Networks Maps (2018)	Habitat Mapping for England. Highlights key areas to reduce fragmentation.	Data is available as separate habitat networks for many priority habitats or as an integrated product. Available on an open licence.
	Condatis	Assesses long distance migration probability, measuring flow through the landscape so helps identify best places for habitat creation.	Requires further expert modelling.
	NBCCVA	Structural habitat fragmentation assessment.	Available on an open licence.
	Forest Research least-cost network approach	Provides least cost path connectivity assessments.	Requires further expert modelling.
	Rangeshifter	Assesses species movement across a landscape, based on habitat suitability, dispersal ability and aspects of population dynamics.	Requires further expert modelling.

Habitat Creation/ restoration	National Habitat Networks Maps (2018) Habitat Potential maps	Habitat Mapping for England. Highlights key areas to create and restore habitats. Provides indication of the potential for an area to support specific habitat creation.	Data is available as separate habitat networks for many priority habitats or as an integrated product. Available on an open licence. Uses soil and other data, which has licence restrictions. Contact Natural England via details below.
Natural Capital and Ecosystem services	Carbon storage and sequestration maps Natural England Ecosystem Services maps and Natural England & CEH Natural Capital maps Natural Capital Assessment Gateway	Climate change mitigation contribution from the natural environment. Maps of ecosystem services and natural capital providing ecosystem services. A web-based gateway to local natural capital assessments and ecosystem services mapping projects.	Uses soil and other data, which has licence restrictions. Contact Natural England via details below. For Natural England data contact Natural England via details below. CEH data available here. Availability varies between local mapping projects, see gateway.
Solution or Action Tools	Zonation Marxan	These can provide suggestions as to the most important places to focus effort and achieve multiple objectives.	Complex tools with high demands for technical skills and data. The tools are freely available online.
Landscape	National Character Area Indicators & Thresholds Mapping Tool	Identifies the effect of agri-environment schemes on landscape character base on National Character Areas.	Available here (see annex 1 for log-in details)

This variety may cause confusion among practitioners. It might appear that there is a long list of alternative approaches to the same question, rather than a range of different tools that consider slightly different aspects. This is why we are attempting to highlight how different models can best be used in this handbook.

Often we will need to use more than one tool or dataset to design an ecological network in a place.

Practicalities

Technical expertise required

As highlighted in Table 1 above, many of the tools and data summarised in this section will require specific technical expertise e.g. use of GIS software and/or some level of technical understanding of ecological networks concepts and tools. This may be available within your organisation, team or project, or you may have to commission this from elsewhere e.g. a GIS team within your organisation or your partnership. Training may also be available to up-skill team members in the use of GIS software. Training may also be required for staff in order to get the most from the functionality of web based tools. The need for technical expertise should be considered in any work that aims to use spatial tools and data.

Updating

Many of these tools and data can only provide a current description or projection for a snapshot in time or a specific scenario (although in some cases many snapshots or scenarios can be produced to show how a project might progress). In many cases the data products will still be very useful, but it is important to understand this limitation. When you combine this with consideration of how regularly contributing datasets are updated (e.g. land cover, site condition, land management activity), it is important to understand the potential for the results to be 'out-of-date', or of different ages, and whether this matters. Therefore you may want to consider whether there is a need to schedule updates to the assessments you do, using these tools. As many spatial tools and datasets only provide an indication of the situation (current or projected), and data updates are likely to be small, the snap-shot results will often remain valid and provide an interpretable addition to the story of your place for a good while.

Incorporating local knowledge

Spatial data and tools do not provide the definitive answer as to where to place ecological networks. They are often very useful decision support tools or discussion starters; the inclusion of local knowledge, expertise and experience is crucial. Plan at a local level to consider use and input by practitioners: include this local expertise and other baseline data (as mentioned above). Any framework or project must be designed to utilise both aspects and, as always, we should work closely with our partners to provide the most useful tools to aid these discussions.

Data needs

For some tools and models you may require other types of information than the spatial data we have listed above in Box 1. This can include information about the ecology of a species that you are interested in. For example, habitat preferences at different life cycle stages or their dispersal abilities, i.e. how far they can travel and what kinds of habitats they will use or travel through.

Here are some examples of the types of ecological data that may be required:

- **Species dispersal information** (See Chapter 2) – you may need this type of information for species relevant to your area. You will get this data from previous studies on the species of interest, however, the existence of this type of data is limited. What you will probably find is that you will make an informed estimate or range of estimates based on the studies of similar species that do exist or you will run a series of different analyses using different dispersal distances in order to give you a range of results that indicate connectivity of networks for a range of different dispersers.
- **Habitat preferences** (See Chapter 2) **–** Species have differing requirements regarding the habitats they live in and move through. They may even have different requirements at different times of the year or lifecycle. You may need to know these requirements to use some of the models. Their ability to move through or otherwise use different land use types, could also be useful information. Furthermore, species will have different responses to the edges of habitat patches, some being more sensitive to 'edge-effects' than others. Again, there have been very few studies to determine this kind of information so the existence of this type of data is limited.
- **Other ecological traits** – this information could include the feeding or nesting needs of species or their reproduction strategy (many or few offspring).
- **Topographical information** – The topography of an area will contribute to determining its ecology and will also contribute to its resilience or otherwise to climate change. Having information about how varied an area's topography is useful in determining where you might want to restore or create habitat for species to use. For example, species may have specific requirements with regard to moisture, hydrology, natural processes and microclimate. A varied topography can also provide more niches for species. An example of a response to climate change may be that a species that requires a warm microclimate and currently occupies north-facing slopes, may start to utilise south-facing slopes as the climate warms. Digital terrain models and LiDAR data are examples of topography mapping that could be useful.
- **Species climate envelope modelling** – This is unlikely to be data you will create yourself, but may be data you will use. Species climate preferences are used alongside climate change projections (e.g. UKCP09) to show how climate suitability may change over time – some areas may become less suitable and other more suitable. It is important to remember that most of this type of analysis does not include any information on the ability of a species to move in to any new 'climate space', as there might be barriers to movement. A project to model species potential range movement in response to climate, the Species Risks and Opportunities project undertook such modelling for 4000 species in England and is described below. Other UK examples of projects that modelled species climate envelopes include BRANCH and MONARCH.

4.3 - Available map-based tools and models

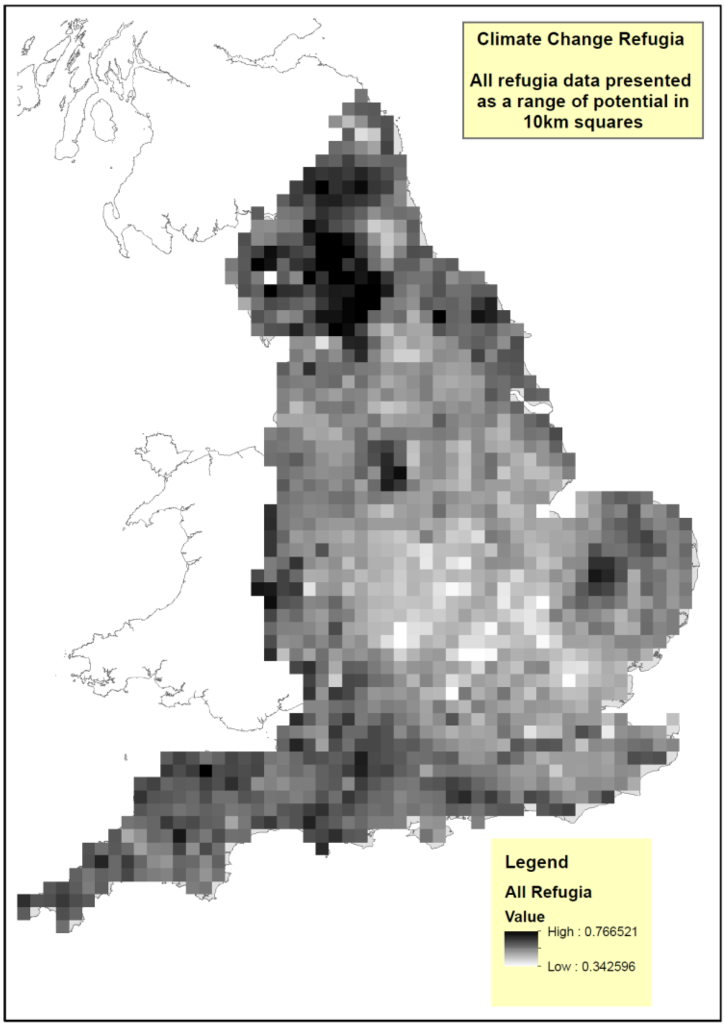
This section provides a short summary of a selection of available models or tools useful in the design of ecological networks for wildlife and people. Please see annex 1 of this chapter for more information:

Maps

4.3.1 Climate change refugia maps (Suggitt et al 2014)

This data identifies geographic areas that are likely to be important for the maintenance of biodiversity in a changing climate. The term 'refugia' is used here to describe areas that are likely to be somewhat sheltered from change or relatively climatically stable in the future and so enable species to persist for longer, despite climate change making surrounding areas potentially unsuitable (see Chapter 2). Properties of the landscape, identified in the literature as contributing to refugium potential, were modelled at 100m resolution for England and summarised at the scale of 10 x 10 km grid squares (Map 1). The survival and extinction of over a thousand species that retracted their range over the past four decades was modelled against environmental properties shown to influence refugium potential e.g. microclimate heterogeneity. The resulting maps may indicate areas that are inherently vulnerable to change and others where refugia should be protected and enhanced, and therefore would contribute more to an ecological network. Map 1 shows a map of refugia potential data for England at a $10km^2$ scale (see annex 1 for more information). The darker areas have the highest refugia potential, having environmental variables, such as high mean elevation, cooler microclimates, high water availability, lower levels of agricultural intensity and lower levels of historic climate change, that are indicative of refugia. The lighter areas contain fewer of these refugia indicators.

Map 1: Climate change refugia map for England

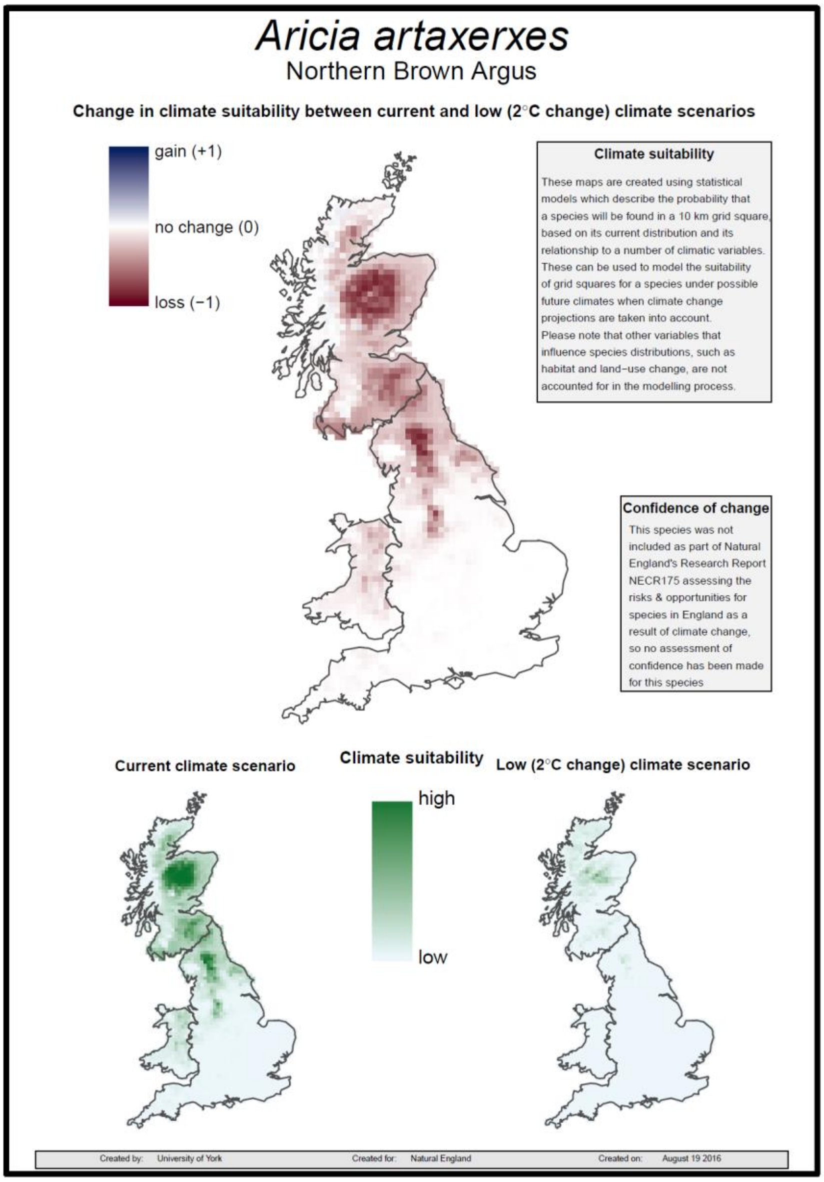


4.3.2 [Assessment of risks and opportunities for species in England as a result of climate change]() (Pearce-Higgins et al 2015)

This project used the latest modelling techniques and analytical frameworks to explore how changes in climate suitability as a result of projected climate change might affect the distributions (and for migratory birds, their population sizes) of species. The analysis was undertaken for 3000+ species of a wide range of terrestrial taxa (from vascular plants and bryophytes to spiders and beetles and birds) and assesses the potential risks within their existing ranges as well as the opportunities that might be provided in new areas. The spatial outputs from this project are maps showing the current and projected changes in the climate suitability of a species in both its historical range and outside its historical range for over 3000 species. They thus suggest whether a species is likely to be threatened by climate change in its historical range and whether a species has opportunities to spread into new areas.

Map 2 provides the modelled results for the Northern Brown Argus butterfly, showing the probability that this species will be found in a 10 km grid square, under a future climate change scenario of $+2^0$C. This modelling is based on its current distribution and its relationship to a number of climatic variables. It is important to note that other variables that influence species distributions, such as habitat and land−use change, are not accounted for in the modelling process.

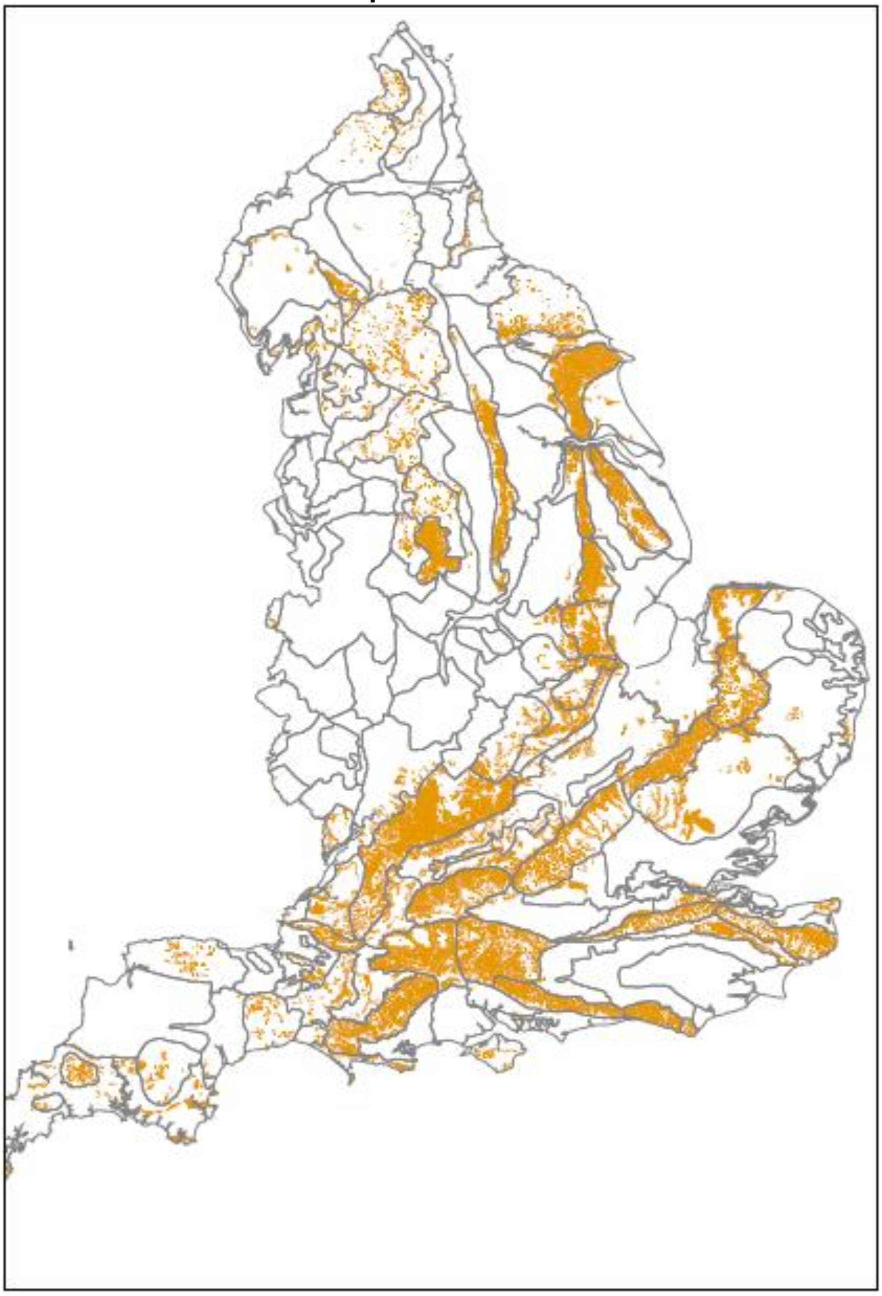
Map 2: Modelled change in climate suitability for Northern Brown Argus, between current and low ($+2^0$C) climate change scenarios (*Source: Pearce-Higgins et al 2015*).



4.3.3 Natural England Habitat Potential maps

These maps show areas where appropriate conditions exist to support the creation of habitat, i.e. it has qualities relating to a particular habitat that suggest that creation and/or restoration is likely to be possible or desirable. This is through the identification of physical conditions, often soil type, that support the creation of particular habitats (see report NECR214). Map 3 shows an example habitat potential map for calcareous grassland.

Map 3 – Example of a Habitat Potential Map for Calcareous Grassland

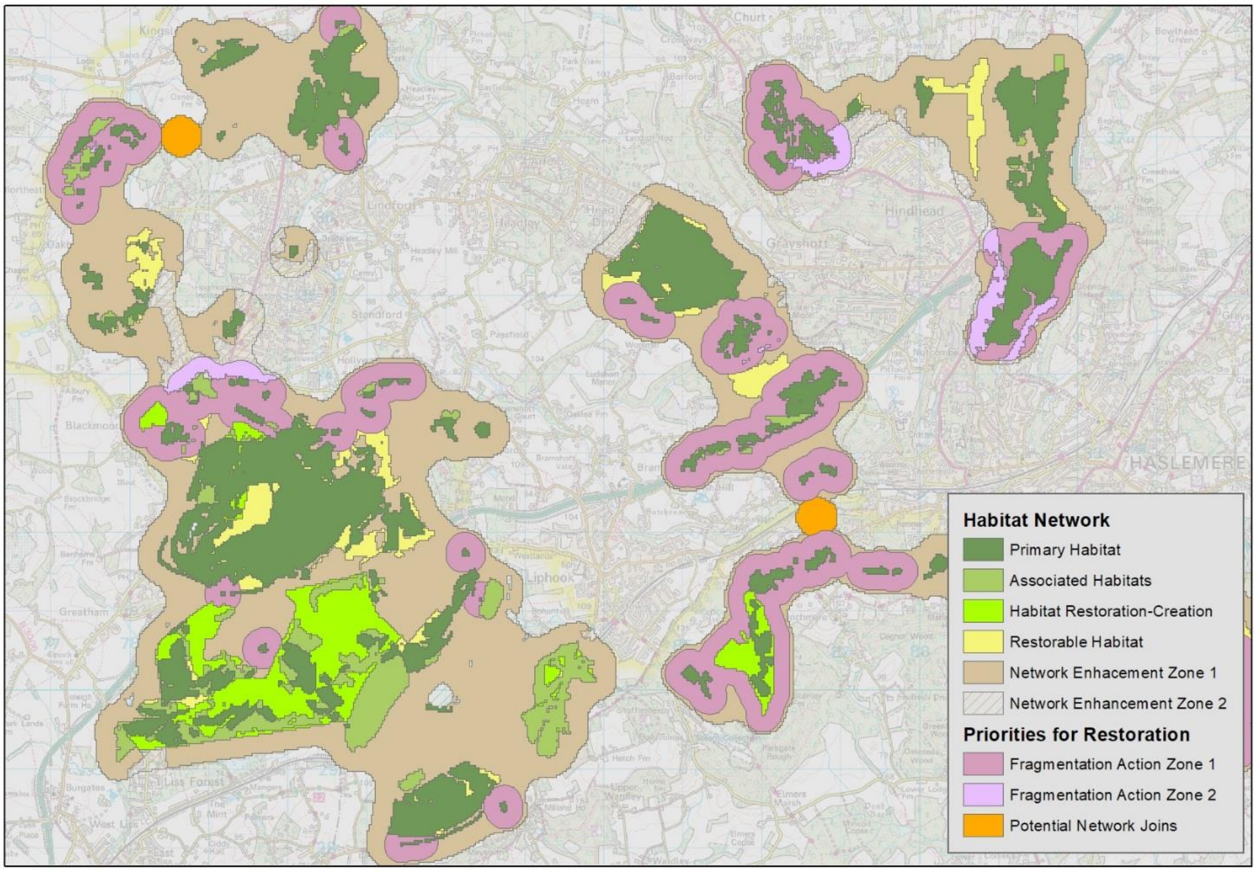


4.3.4 National Habitat Network (NHN) maps (Edwards et al 2018, unpublished)

These are a set of national scale maps based on the [Natural England Priority Habitat Inventories]() that combine data to represent a national habitat network for a number of priority habitats. These national habitat network maps can be used to contribute to the creation of a local ecological network, alongside local information, data and knowledge. They can assist in identifying priorities for habitat restoration and creation in order to enlarge existing habitat patches and reduce fragmentation.

Map 4 below illustrates the NHN components that together provide suggested habitat creation and restoration priorities. The **Primary Habitat** shows the current presence of a priority habitat for which the network is being developed. The **Habitat Group** shows the location of other priority habitat types that form a mosaic or an ecologically coherent grouping that is used by species associated with the primary habitat. **Restorable Habitat** shows areas that are classed in habitat inventories as degraded habitat types associated with the primary habitat and areas that are currently undergoing appropriate habitat restoration work. The **Network Enhancement Zone** is the result of a variable buffering process around the three above components to identify clusters where actions to enhance current habitat networks could be targeted. This zone captures areas of degraded habitat, and areas with suitable soils etc. surrounding existing priority habitat that are likely to be suitable for habitat restoration and creation and are in good locations to enhance and build the resilience of the current habitat network. The **Fragmentation Action Zones** and the **Potential Network Joins** are two elements that help highlight priorities for restoration, a) smaller fragmented areas of existing habitat that have the potential to be enlarged or joined with other habitat patches and b) links between sections of the network enhancement zones that have potential to join up parts of the network.

Map 4 Natural England National Habitat Network Map Example

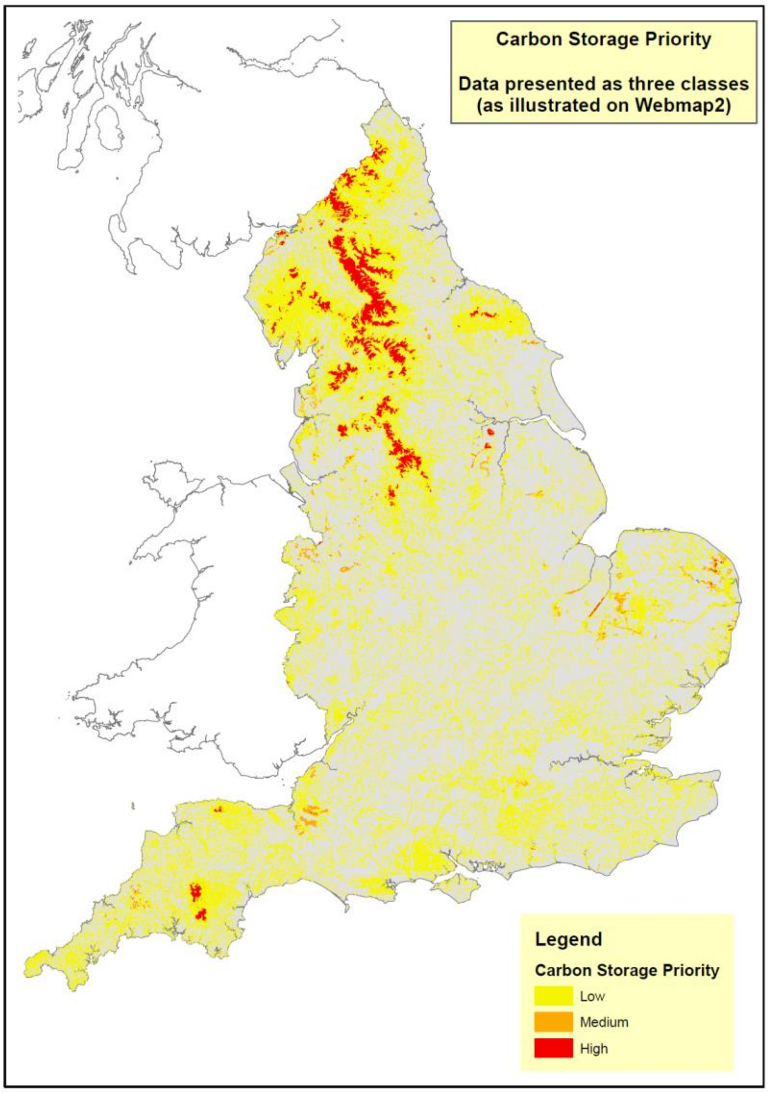


5.3.5 NE Carbon storage and sequestration maps (Natural England/Amec report unpublished)

These maps identify both Carbon Storage and Carbon Sequestration Priorities. The Carbon Storage Priority data identifies and maps current carbon storage, highlighting areas of high carbon density that require protection to prevent further carbon loss. The Carbon Sequestration Priority data identifies and maps future carbon storage potential areas where carbon storage could be increased with positive land use change (e.g. when changing from arable to grassland carbon emissions from peat is massively reduced).

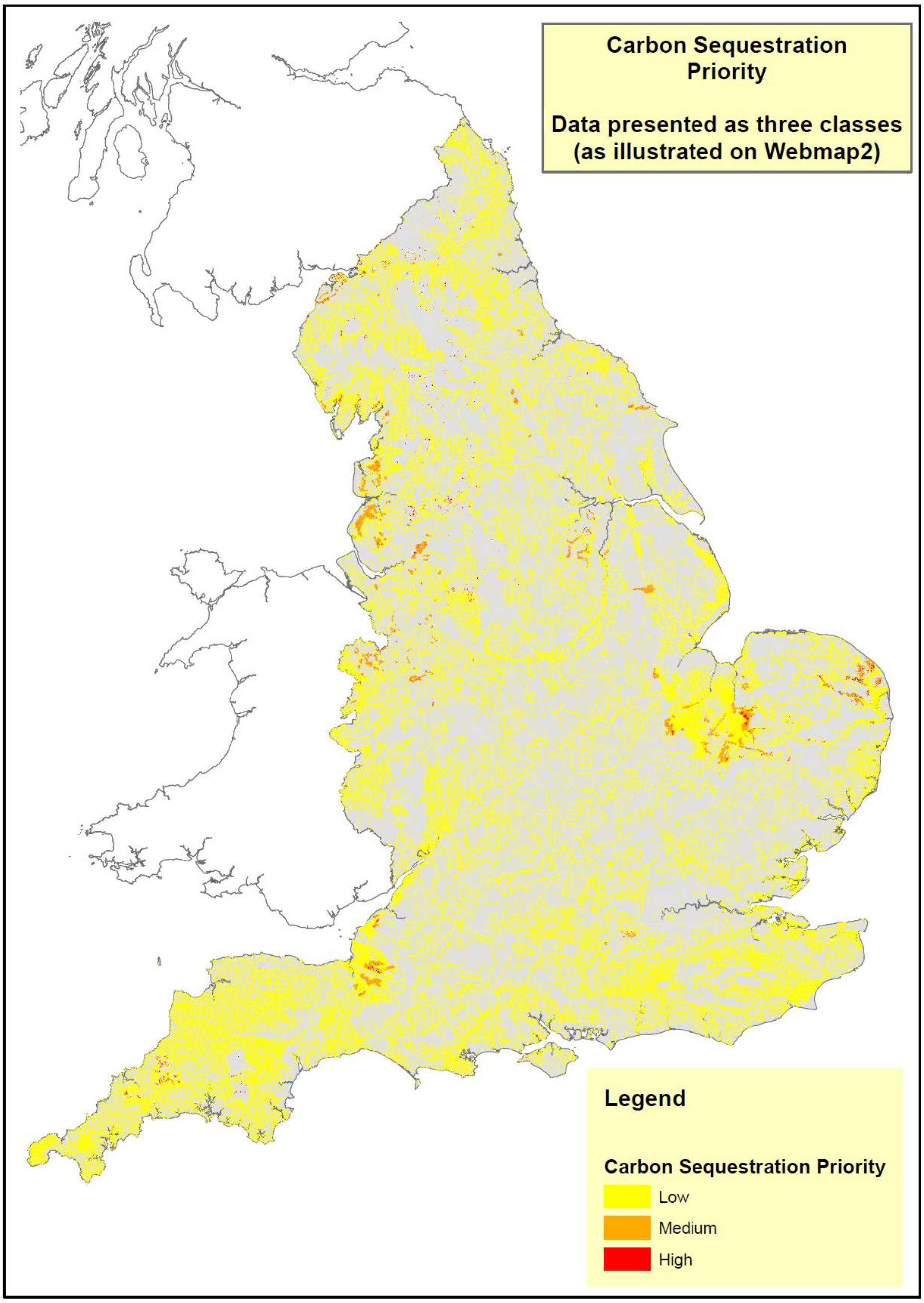
Map 5 shows where the Carbon Storage Priorities data for England has identified current carbon storage, highlighting areas of high carbon density that require protection to prevent further carbon loss or to avoid becoming a net carbon source. High values represent the presence of a peat based soil of significant depth (over 1.5m), probably due to only a small amount of disturbance over time and under positive management for carbon storage (e.g. undrained lowland raised bog). Medium values show where there is peat soil still of significant depth (over 1.5m) but will have had land management practices that will have reduced the original peat depth and the capacity of the habitat to store carbon (e.g. grazed wet grassland). Low values represent where the habitat has a lower ability to store carbon, as much has already been lost historically, or has been significantly affected by carbon loss due to an extended period of incompatible land management (e.g. arable management on peatland soils).

Map 5 Carbon Storage Priority (*Source: NE Carbon Storage and Sequestration Maps*)



Map 6 shows where the **Carbon Sequestration Potential data for England** has identified future carbon storage potential areas where carbon storage could be increased due to positive land use change. High indicates areas that are losing carbon to the atmosphere at a very high rate through oxidation (e.g. arable management on peatland soils), where a change in land use could significantly reduce carbon loss and promote sequestration. Medium highlights areas with moderate carbon loss with potential to reduce the rate of loss (e.g. improved grassland over peatland soils). Low shows areas with high carbon storage capacity already under sympathetic management (e.g. wetland habitats under restoration).

Map 6 Carbon Sequestration Priority (*Source: NE Carbon Storage and Sequestration Maps*)

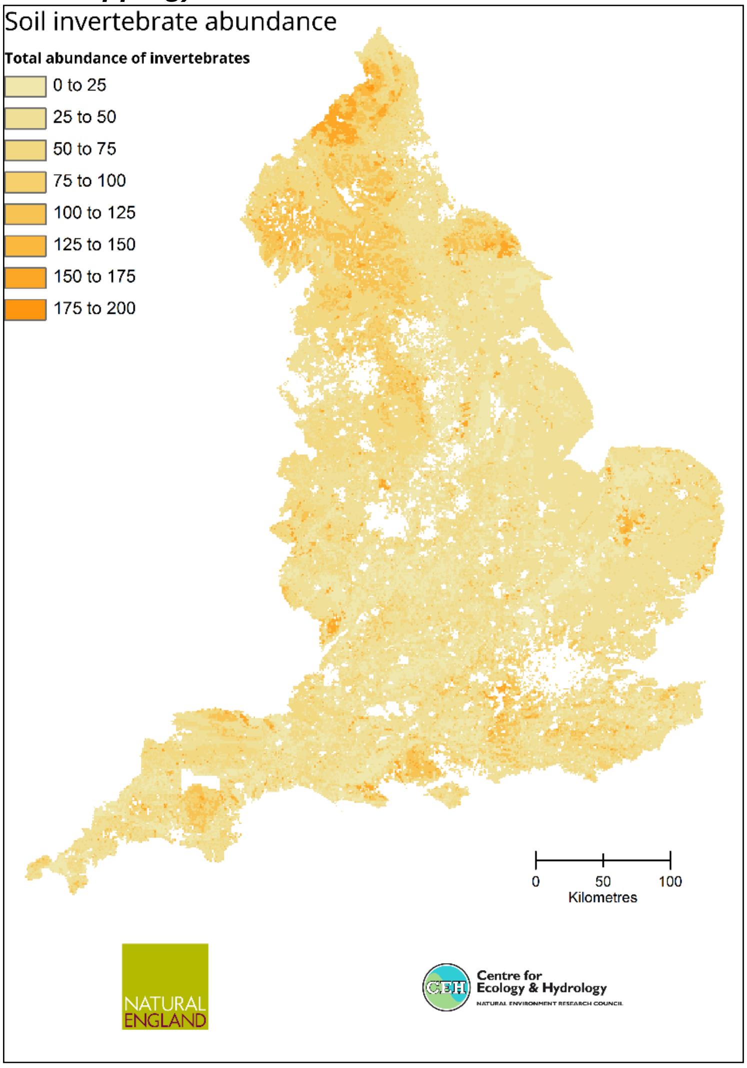


5.3.6 [Natural Capital Mapping](#) (CEH and Natural England, 2016)

This provides publically accessible 'off-the-peg' maps of natural capital in England, without the need for additional data input or modelling. Ten maps are available: soil carbon, soil pH, soil nitrogen, soil phosphorus, soil invertebrates, soil bacteria as well as headwater stream quality (based on invertebrate assemblages), plant indicators of good habitat condition, above ground carbon and nectar plant diversity for bees. The maps are accessible to view or download as high quality images or GIS layers. Users can take a map away and combine it with other GIS layers, or cut it to the part of the country that they are interested in. Accompanying text details what the map shows and how it has been produced. The maps are produced using a range of datasets, including CEH sample data from the Countryside Survey (2007). CEH's Ecomaps tool has been used to produce maps at an England level through statistical interpretation and extrapolation from the sample data. Maps show mean value for a 1km grid square and standard error from the mean, showing uncertainty. This has been developed by Natural England and CEH.

As an example of these maps, Map 8 shows mean estimates of total abundance of invertebrates in topsoil (0-8 cm depth). Soil invertebrates have an important role in soil processes. This includes storing, filtering and transforming nutrients, as well as plant growth. Soil invertebrates are fundamental to maintaining soil quality, which underpins almost all other regulating ecosystem services. This map was produced by using measurements of total number of invertebrates extracted from soil cores in the Centre for Ecology & Hydrology Countryside Survey (2007) at 927 sample locations across GB within 238 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on the total number of invertebrates extracted associated with a combination of habitat type and soil parent material (the geological material, bedrock, superficial and drift, from which soil develops).

Map 7: Invertebrates in topsoil: mean estimates of total abundance (*Source: Natural England and CEH Natural Capital Mapping)*



5.3.7 **[Natural England Ecosystem Services Maps]** (Dales, Brown and Lusardi, 2014)

These are England level ecosystem service maps for ten different ecosystem services. They were created using a simple methodology derived from the National Ecosystem Assessment (NEA 2011) and based on habitat maps as a proxy for service provision. The ecosystem services represented are – climate regulation, pollination, air quality regulation, soil function, water quality, water supply, wood provision, food provision, wild species diversity and cultural services.

5.3.8 **England Habitat Network, Natural England** (Catchpole, 2008)

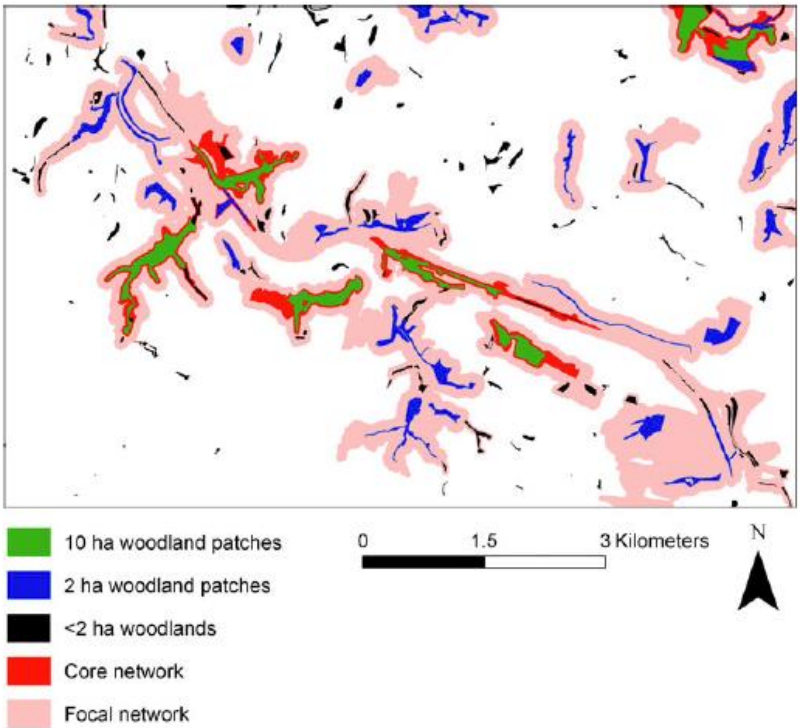
This assessed England's ecological network by identifying areas between sites that may support the movement of individuals by assessing land use types. It did this by using a least-cost path model, i.e. modelling whether existing habitat patches are connected for a focal species, based on generic dispersal ability and habitat preferences (the same approach as outlined by Forest Research below). The method estimates potential movement envelopes around existing patches of habitat that can then be used to define the buffer zones and functional 'corridors' through which a species is able to move. Where more than one of these envelopes overlaps, a network is formed. This data was one of the first attempts at habitat network analysis Natural England undertook, we have developed our approaches to habitat networks since this was produced, but it provided a starting point for much onward work. It was used in the 'Making Space for Nature' report (Lawton et al 2010) and so is included here for context and completeness.

Models

5.3.9 **[Forest Research least-cost network approach]** (Watts et al, 2010)

This uses a least-cost path model to assess the ecological function of a landscape under certain parameters. This essentially means that landscapes are assessed for the arrangement of habitat patches and ease of movement between them for generic, or indicator, species, using dispersal distances and habitat preferences and barriers, analyse the functional connectivity of landscapes. Map 8 below, shows an illustration of an output from this approach from Watts et al (2010) of a "modelled core and focal networks[s] for broad-leaved woodland generic focal species in the existing landscape".

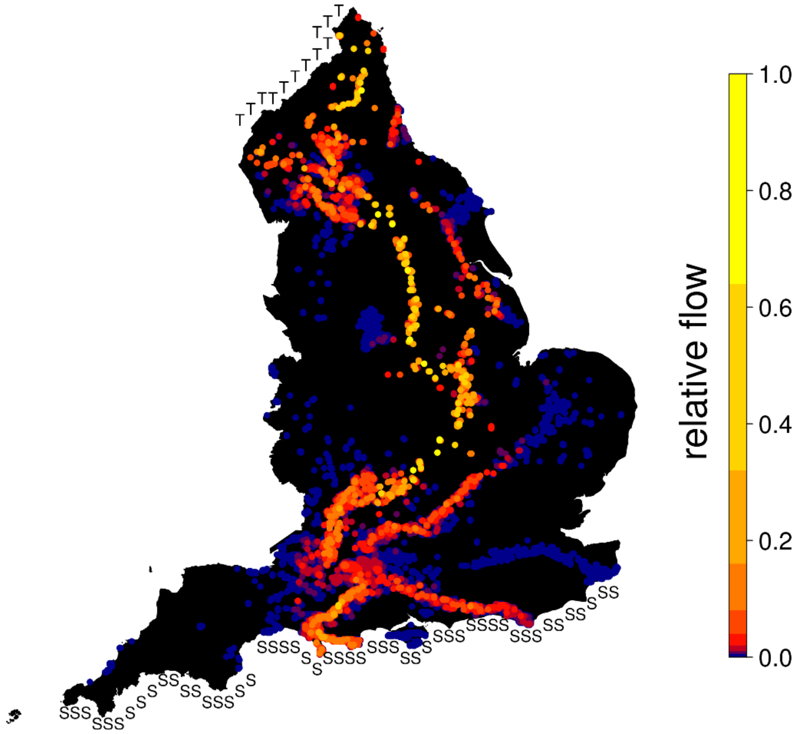
Map 8: an example output from the Forest Research Least-cost approach.



5.3.10 Condatis (Hodgson et al, 2012)

Condatis is a decision support tool that helps identify the best locations for habitat creation to increase connectivity across landscapes. Condatis is based on the analogy of electrical circuit boards (wires and resistors) as a way to represent landscapes and model the way a species moves through them. The ability of species (the electrical current) to move through the landscape (the circuit board) varies depending on the configuration of the habitat patches (the wires and resistors). The tool uses a source/destination approach that replicates the movement of a species across latitudes or altitudes in response to climate change. See map 9 for an example Condatis output.

Map 9: An example of a flow output from Condatis for Lowland Chalk Grassland Habitat using a 4km dispersal distance with the source defined as the south coast of England (S) and the destination the border between England and Scotland (T), using only priority habitat data for England (Source: Unpublished report Hodgson et al, 2018).



5.3.11 RangeShifter (Bocedi et al 2014)

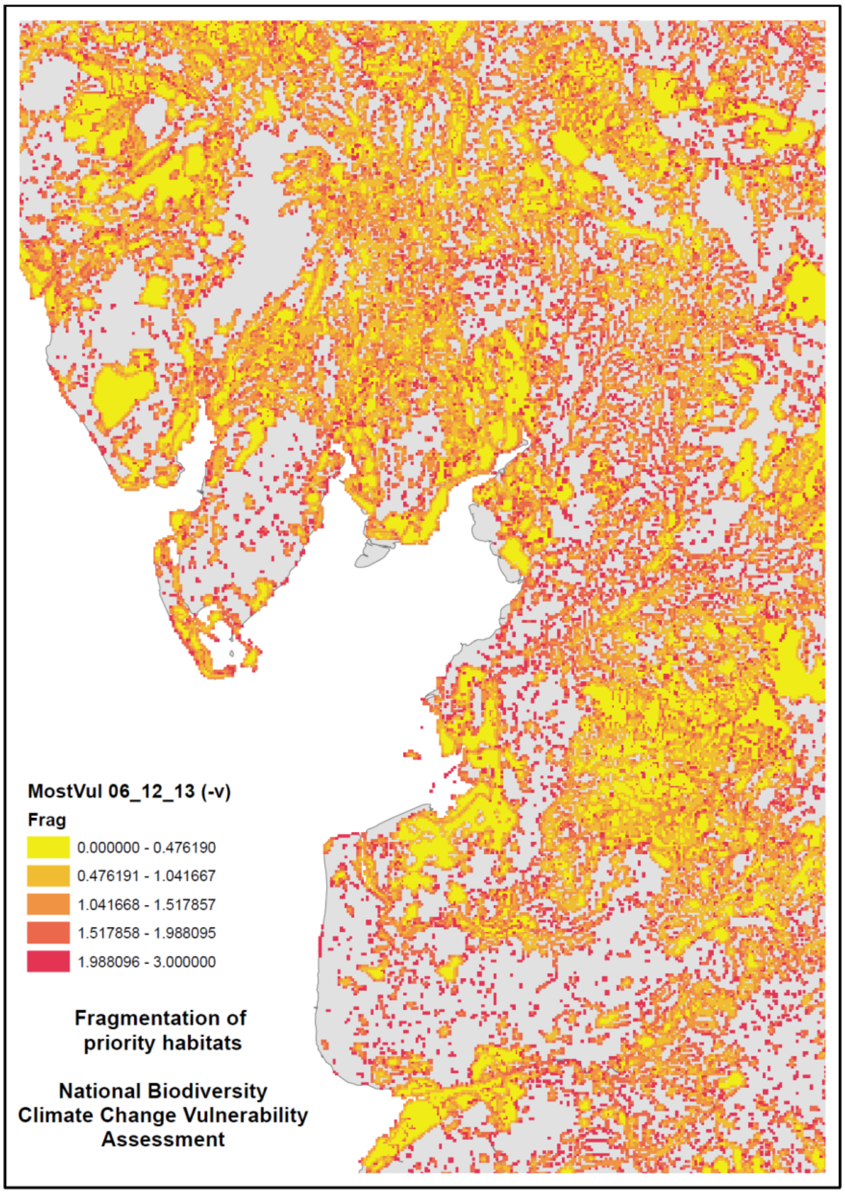
This tool integrates aspects of population dynamics and dispersal behaviour to model the spread of a species across a landscape. Different habitats can have different suitabilities in terms of how well a species thrives and disperses. The software shows where a species might colonise and at what population densities, but it needs to be run multiple times because it has random factors built in, so each run is different. The software can address applied questions - it can be parameterised for real landscapes and species to compare alternative potential management interventions - or purely theoretical studies of species' eco-evolutionary dynamics and responses to different environmental pressures.

5.3.12 Natural England National Biodiversity Climate Change Vulnerability Assessment (NBCCVA) and Tool (Taylor, Knight and Harfoot, 2014)

The NBCCVA tool provides an assessment of the relative vulnerability of priority habitats to climate change in different places. It identifies why areas might be vulnerable thereby suggesting which possible interventions might have the biggest impact in increasing resilience to changing climate using a series of metrics representing sensitivity, fragmentation, topography and condition. It is a flexible, GIS based, decision support tool, to which users can incorporate local datasets.

Map 8 shows the results of the Habitat Fragmentation metric for an example area around Morecambe Bay. The range of colours represent the range of fragmentation of habitats. This broadly shows that more semi-natural habitat in consecutive cells leads to less fragmented habitats. For example the larger contiguous areas of priority habitat are highlighted in yellow, and have low fragmentation scores. This metric can help to identify areas that may benefit from greater concentration on reducing habitat fragmentation, the orange and red areas.

Map 10: Habitat Fragmentation Metric for an example area around Morecambe Bay *(Source: NE NBCCVA)*



5.3.13 [Natural Capital Assessment Gateway] (Ecosystems Knowledge Network, University of York, Natural England, BBSRC and NERC)

The Natural Capital Assessment Gateway brings together information on the growing number of projects in the UK concerned with mapping and assessing natural capital and ecosystem service delivery at the local, regional or national level. It provides an interactive, searchable, map-based facility to explore projects in progress or completed across the UK. This is an update on the Biodiversity Ecosystem Services Sustainability Programme.

5.3.14 National Character Area (NCA) Indicators and Thresholds Mapping Tool (Natural England)

This tool is based on a comprehensive set of indicators and thresholds to measure the significance of change in landscape character through environmental stewardship, which can be used for scheme monitoring. Indicators relate to landscape character objectives for each NCA, within 7 landscape themes: woodland and trees; boundary features; agricultural land uses; traditional farm buildings; the historic environment; semi-natural habitats; and the coast. See annex 1 for tool log-in details.

Systematic Conservation Planning

5.3.15 Marxan (Ball and Possingham 2004)

Marxan is one of the main tools used in systematic conservation planning, (see also Zonation below). Systematic conservation planning seeks to identify networks of conservation areas that are Connected, Adequate, Representative and Efficient (CARE);

- **Connected** refers to the need for the conservation areas to form a network, so that individuals and propagules can disperse through their landscapes and seascapes, and species can change their ranges in responses to local and global change.
- **Adequate** refers to the need for conservation areas that contain enough of each biodiversity element to ensure the long term persistence of biodiversity.
- **Representative** refers to the need for conservation areas that represent biodiversity in all its forms, although this generally relies on using surrogates.
- **Efficient** refers to the need to ensure that conservation area networks minimise management costs and opportunity costs to other sectors (Kukkala & Moilanen 2013).

Defining the objectives of the conservation area network is probably the key difference between systematic conservation planning and other similar approaches, and is critical for developing a shared vision and set of goals. Having defined the objectives for an area, then Marxan can be used to identify the priority areas needed to meet those goals, in a CAREful way (Connected, Adequate, Representative and Efficient). Importantly, the tool can also include other landuses and factors that need to be taken into account – thus is can aim to conserve biodiversity, while, for example, maximising goals for carbon storage or avoiding land that is under high-grade agricultural cultivation. The output of Marxan can be imported into GIS software to create maps or for further analysis. Marxan can be freely downloaded from its website.

5.3.15 Zonation (Moilanen and Kujala 2006)

Zonation is also a tool that can be used within a Systematic Conservation Planning exercise. Instead of building up the areas of priority by choosing the most important areas, it iteratively removes the least valuable remaining areas while accounting for connectivity and generalized complementarity. Like Marxan it can incorporate other factors that can be treated positively (e.g. carbon storage) or negatively (e.g. urban area). So, Zonation differs from Marxan in that it doesn't require targets to be set, but it identifies the relative priority of areas required to conserve a range of user-specified species, taking into account the other factors. The output of Zonation can be imported into GIS software to create maps or for further analysis. Zonation can be freely downloaded from its website.

4.4 Contact us

Contact Information - The use of maps, tools and models, the range of available data and the licence issues that go with them, is often confusing and it can sometimes be unclear how you get hold of the information you need. Data and tools are also constantly changing as websites get updated and new approaches become available. We have tried to be as up to date as possible in this chapter, but we know things will change. We plan to update this Handbook as things change, but please do contact us to discuss any of the data and tools discussed above:

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Natural England Open Data Portal – http://naturalengland-defra.opendata.arcgis.com/
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