Gloucestershire Natural Capital Mapping Project

User Guidance:

Interpreting the Nature Recovery Network Mapping

Gloucestershire Wildlife Trust

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Definitions

Core habitat patch or habitat patch – an area of contiguous priority habitat or semi natural habitat as defined under the ecological networks. Areas of habitat are considered contiguous if gaps between them are no greater that 10m.

Network – an area of core habitat patches that are considered to be connected within a set cost distance.

Core network - an area of core habitat patches that are connected within a 500m cost distance.

Ecological network - all of the core habitat patches and all networks (at the specified cost distance) for a given set of habitat types. These habitat groupings are based on the National Ecosystem Assessment groupings.

Nature Recovery Network – a group of maps that put together provide information on the location of habitats, current connectivity and restoration/creation opportunities for the full suite of priority habitats within the county.

Site – this has various meanings in different documents depending on the context. It may be a single habitat patch. It may mean a designated site, local wildlife site or nature reserve which may have a range of habitats within it. When documents talk about minimum areas for sites this may mean area of functionally connected supporting habitat rather than a single habitat patch, essentially the area of core habitat within a "network" as defined above.

Introduction

Humans and nature rely on functioning ecosystems to provide all the services required for survival. Pressure on the environment from humans has resulted in the loss and fragmentation of habitat. Each species has specific requirements for survival which will include obtaining enough food and water, finding a mate, finding shelter etc. Parameters which affect a species' ability to fulfil these requirements are the patch sizes of suitable habitat available to them (minimum viable area), the species' ability to disperse (dispersal distance) and the distance between the patches (connectivity).

In the assessment of the state of the England ecological network, the Lawton review 2020 stated that it was not fit for purpose, sites were too far apart and separated by too hostile an environment to support the movement of species for both general survival and in the face of migration required to mitigate for climate change. The phrase Better, Bigger, More and More Joined was coined in the review, and are the principles held to for expanding ecological networks in the UK.

In order to create a functional ecological network, i.e. one where the suitable patches of habitat are not necessarily physically connected, but are close enough and separated by a permeable enough matrix to enable species movement between patches, we need to protect and maintain (Better) and restore outwards (Bigger, More, More Joined) from the existing good quality semi-natural habitat that we still have.

The Nature Recovery Network mapping follows these principles.

Step 1: understand what we already have, core patches and surrounding habitat/land use (produce complete cover habitat/land use map and core habitat patches).

Step 2: understand how connected the core patches of the network currently are at a range of dispersal distances to cover a number of species groups (connectivity mapping).

Step 3: look at how resilient and coherent individual core patches and networks of functionally connected patches are (informs step 5).

Step 4: map network expansion that would reinforce the core networks i.e., the area close to existing good habitat (NRN mapping)

Step 5: map strategic restoration areas; these are the bigger gaps between networks that need bigger investment in larger projects to deliver restoration across a large area.

Natural Capital mapping - NRN and ecosystem service maps

Our natural capital assets, i.e. habitats and species (biodiversity), underpin the delivery of ecosystem services that support the survival of all populations including the human population. Both the NRN and ecosystem services maps are built from the same county wide complete coverage habitat map.

The NRN focuses on showing where the restoration of habitat networks needs to be carried out to support nature restoration from an ecological perspective. It does not consider where habitats could be restored or created to deliver other ecosystem services rather than specifically nature restoration.

The ecosystem service maps show which locations are currently delivering specific ecosystem services. The measure of current ecosystem service delivery is based on how much the existing underlying habitat is thought to contribute to that ecosystem service. For example, wetlands contribute to flood regulation more than a hard sealed surface would.

By comparing the ecosystem service and NRN maps you can determine where habitats are supplying critical ecosystem services that if removed would have serious knock on effects. You can also examine where delivery of particular ecosystem services are lacking and consider what habitat enhancements could deliver that ecosystem service.

Where a number of different habitats could deliver an ecosystem service the NRN helps to guide which habitat enhancement would also deliver the most for biodiversity by simultaneously enhancing the nature recovery network (multiple benefits).

The aim is that enhancements for ecosystem services should always deliver the maximum potential benefit for biodiversity, as biodiversity underpins all ecosystem services.

Interpreting the NRN map layers

There are a number of mechanisms that will help to deliver restoration of the NRN. To make it easier, each mechanism has a tailored guide to interpretation below:

Local Planning Authorities and the planning process.

Mechanisms for the protection and enhancement of the NRN through planning/development control include:

- *Protection*: Identification of core habitat (largely NERC section 41 priority habitat) – the Gloucestershire complete cover habitat inventory provides best available data on the habitats or land use to detailed OS mastermap polygon scale. Core habitats (see methodology for detail) have been extracted from the habitat inventory. The **core habitat layers** display the locations of the core habitats used to derive the networks. Core habitats act as the species source for the expansion of the network.

- *Protection:* Identification of the core network - this is the **core habitat and the connectivity within a 500m cost distance**; equivalent to a 500m dispersal distance but adjusted for the permeability/cost to movement of the underlying habitat (see methods for more detailed explanation of cost distance and permeability). This enables the appropriate protection, or mitigation of connectivity within the core network to be identified. Breaking of critical connectivity should be avoided. Larger dispersal distances are also provided as layers to illustrate the connectivity for more mobile species.

- *Protection:* Network context for sites – proposed development sites can be considered against their current contribution to the network, whether they are a critical link.

- *Enhancement:* On site delivery of net gain – can be informed by the NRN and wetland opportunity mapping which indicates the network and priority level of a location for restoration.

- *Enhancement:* Off-site delivery of net gain – can be informed by the NRN and wetland opportunity mapping, or the strategic restoration areas as determined by the Gloucestershire Local Nature Partnership. Off-site delivery of net gain would provide a prime opportunity for creating those larger landscape connections within the bigger gaps in the network. Proposed off-site delivery sites could be assessed against the NRN and wetland opportunity mapping and strategic restoration areas to see whether they would contribute to the resilience and coherence of the NRN. Sites outside of these areas should not necessarily be dismissed, but need to consider mechanisms to link them to the network, e.g. managing land between the site and the network to make it more permeable to species movement, adding corridors or stepping stones.

- *Monitoring:* the impact of local policy delivery on the resilience of ecological networks can be monitored using the following, the relevant Lawton principles are shown in brackets.

  Within the local planning authority boundary:
  - Total area of core habitat (Bigger/More)
  - Area of core network (connectivity at 500m cost distance) - can be assessed against functional thresholds (More joined)
  - Area of wider permeability (connectivity at 5000m cost distance) (More permeable matrix)

  Off-site net gain delivery if outside the local planning authority boundary:
  - Area of core habitat created or restored (Bigger/More)
  - Area of associated core network (connectivity at 500m cost distance) - can be assessed against functional thresholds (More joined)

Environmental land management

Agri-environment schemes are one mechanism for funding work in the wider countryside to benefit nature while maintaining food production. Alternatively, organisations or individuals that own or farm land may wish to proactively support nature on their land without being part of a government scheme. The principles for interpreting the network mapping are the same for both groups.

Note that the maps are modelled from best available data but some of this data may be out of date or based on interpretation of satellite data. While the Gloucestershire Wildlife Trust is aiming to develop a county wide habitat survey scheme to keep the habitat data up to date,

information contributed by landowners (and access for survey) is invaluable and makes the network mapping across your land much more reliable.

The ***core habitat*** layers under the ***Nature Recovery*** menu indicate where there are records of priority (NERC Section 41) or other core habitat on your or adjacent land. These habitats are a priority to maintain or bring into good condition with appropriate management.

The ***NRN*** and ***Wetland opportunities*** layers illustrate the priorities for habitat restoration to make the networks more resilient and can be used to guide the positioning of agri-environment scheme options (see Table 1) or similar activities. In high and medium priority areas the aim is to restore/create the network's core habitat type. In low priority areas the aim is to increase the general permeability, of the wider landscape, to species movement. Field margins, hedgerows, in field trees etc can all help to do this, as can a reduction in agricultural intensity (e.g. reduced grazing intensity, low or no inputs of fertilizer or pesticides). Agro-forestry is another possibility for increasing landscape permeability.

Network connectivity can also benefit from aligning field margins to create corridors between patches of core habitat.

If you have a number of core habitat patches withing your land, or if you own a number of areas of land and want to prioritize where to start, the ***Nature Resilience*** maps can help:

Open or Woodland patch viability - this is the area in hectares of each core habitat patch and can be used to consider whether patches meet minimum viable patch size requirements to support particular species or groups of species. In general terms you do not want core patches below the minimum threshold for the network (i.e. the red patches). These are a priority to expand in size.

Woodland or Open habitat network viability - If you have core patches that are part of a network within these layers, you can look at how resilient that network currently is. Does it meet the minimum threshold or is it below the threshold and marked as red. If red, this is a priority; you could increase the number of patches within this network (ensuring they are greater than the minimum viable patch area) or expand the area of existing patches. The NRN layer can help to show where expansion could take place to increase the overall resilience of the ecological network.

Advice can be sought from a number of organisations though their time may be chargeable.

Table 1: Countryside Stewardship options that can contribute to the ecological networks

Network element	Option code	Option title
Open Habitats Core sites	BE4*	Management of traditional orchards
	BE5	Creation of traditional orchards
	GS6*	Management of species-rich grassland
	GS7	Restoration towards species-rich grassland
	GS8	Creation of species-rich grassland
	LH1	Management of lowland heathland
	LH2	Restoration of forestry and woodland to lowland heathland
	LH3	Creation of heathland from arable or improved grassland
	WD5	Restoration of wood pasture and parkland
	WD6	Creation of wood pasture
Open Habitat Network corridors, stepping stones and wider landscape permeability (largely for invertebrates rather than plants)	AB1*	Nectar flower mix
	AB3*	Beetle banks
	AB6*	Enhanced overwinter stubble
	AB7*	Whole crop cereals
	AB8*	Flower-rich margins and plots
	AB9*	Winter bird food
	AB10*	Unharvested cereal headland
	AB11	Cultivated areas for arable plants
	AB14*	Harvested low input cereal
	AB15*	Two year sown legume fallow
	AB16*	Autumn sown bumblebird mix
	GS1*	Take small areas out of management
	GS4*	Legume and herb-rich swards
	OP4*	Multi species ley
	OP5*	Undersown cereal
	SW1*	4-6m buffer strip on cultivated land
	SW2*	4-6m buffer strip on intensive grassland
	SW4*	12-24m watercourse buffer strip on cultivated land
Wooded network core sites	WD1	Woodland creation - maintenance payments
	WD2	Woodland improvement
Wooded network corridors, stepping stones and wider landscape permeability	BE3*	Management of hedgerows
	BE4*	Management of traditional orchards
	BE5	Creation of traditional orchards
	WD5	Restoration of wood pasture and parkland
	WD6	Creation of wood pasture
Wetland network core habitats	CT3	Management of coastal saltmarsh
	CT4	Creation of inter-tidal and saline habitat on arable land
	CT5	Creation of inter-tidal and saline habitat by non-intervention
	CT7	Creation of inter-tidal and saline habitat on intensive grassland
	GS9*	Management of wet grassland for breeding waders
	GS10*	Management of wet grassland for wintering waders and wildfowl
	GS11	Creation of wet grassland for breeding waders
	GS12	Creation of wet grassland for wintering waders and wildfowl

	HS7	Management of historic water meadows through traditional irrigation
	SW12	Making space for water
	WT6	Management of reedbed
	WT7	Creation of reedbed
	WT8	Management of fen
	WT9	Creation of fen
	WT10	Management of lowland raised bog
	WT3*	Management of ditches of high environmental value
Wetland network corridors, stepping stones and wider landscape permeability	WT4	Pond management (areas more than 100 sq m)
	WT5	Pond management (areas more than 100 sq m)
	SW11*	Riparian management strip
	WT1*	Buffering in-field ponds and ditches in improved grassland
	WT2*	Buffering in-field ponds and ditches on arable land

*Mid-tier options, those without asterisks are higher-tier options

Landscape scale nature recovery project planning

Core habitat patch and network metrics can be used to help identify recovery project areas and restoration activities within project areas. The simple metrics under the **Nature Resilience** menu are:

- Woodland habitat patch viability (patch size judged against minimum viable areas for species groups)
- Open habitat patch viability (patch size judged against minimum viable areas for species groups)
- Woodland network viability (total area of core habitat within a network judged against suggested thresholds for species groups).
- Open habitat network viability (total area of core habitat within a network judged against suggested thresholds for species groups).

These simple metrics provide a quick and rough illustration of patch and network resilience, the thresholds are given in the layer legends, suggested actions are detailed in Table 2.

More detailed patch and network metrics adapted from the Forest Research BioCORE tools can be provided on request to further help identify recovery project areas and restoration activities within project areas. More detail on BioCORE, and an example of application, can be found in Somerset Wildlife Trust's Mendip Ecological Network Restoration Area: Identification and Recommended Actions. The networks and habitat patches can be ranked for coherence (connectedness) and resilience (ability to resist and recover from damaging events). How you use this data then depends on the aims of your project:

1. Looking to make your own sites more ecologically resilient?

- Use the patch and network metrics to examine the current status of habitat patches within or linked to your site. Actions related to each metric are given in the table below.

2. Developing projects to bridge strategic gaps in the ecological networks?

- Examine the metrics for the habitat patches within the strategic gap and adjacent networks. What are they failing on? Use the table of suggested actions to inform possible solutions.
- There are various suggested minimum habitat areas suggested for different species groups or habitat types. The **Nature Resilience** layers provide information on how networks and core habitat patches fit within these ranges.
- Actions need to consider how overlapping networks relate to each other so that you do not enhance one to the detriment of the other.

Table 2. Adapted from Mendip Ecological Network Restoration Areas: Identification and Recommended Actions, 2016, Somerset Wildlife Trust and Evaluating the Functionality of Ecological Networks in the Brue Valley Living Landscape through the Assessment of Ecological Coherence and Resilience, 2015, Moseley et al. Entries in italics are additional metrics added by Gloucestershire Wildlife Trust. The metrics highlighted in bold provide overall ranking of the patches and networks for coherence and resilience within the modelled Gloucestershire NRN area (Gloucestershire plus 2km).

Habitat Patch Coherence			
Metric	Description	Justification	Action if identified as the failing
Interconnectivity	This relates to the number of Habitat patches within a set buffer.	A higher number indicates a greater amount of connectivity, so habitat patches with a high score are considered to be more coherent.	Work to create and restore habitat within the same ecological network. Ideally habitat created should be at least the size of the Minimum Viable Area for that ecological network so that new dispersal areas are created or existing dispersal areas are extended. All stepping stones and core areas in the network should be retained and their quality improved. Structural connectivity between habitat patches could be improved through actions such as restoring hedgerows or road verges.

Proportional cover	The area of core habitat surrounding each habitat patch within a fixed dispersal distance (e.g. 500m buffer)	Patches with a greater proportion of surrounding habitat are considered to be more coherent.	Work to create and restore habitat within the same ecological network. Ideally habitat created should be at least the size of the Minimum Viable Area for that ecological network so that new dispersal areas are created or existing dispersal areas are extended. All stepping stones and core areas in the network should be retained and their quality improved. Structural connectivity between habitat patches could be improved through actions such as restoring hedgerows or road verges.
Patch location score	Each habitat patch was assigned a score according to its location within 500m increments up to 5km	Core habitat was assigned the highest score; habitat within the initial network at the recommended dispersal distance was given the next best score. The networks were then run at increasing dispersal distances up to 5km. Habitat patches were given a decreasing score according to the network they were included in. Habitat not included in any network was given the lowest score of 1.	
Habitat coherence rank	(Interconnectivity score + proportional cover score)*Patch location score	Each habitat patch is assigned a 'Coherence Rank', with the highest scoring habitat patch assignedthe best rank of 1.	Depends on your focus but if you are looking to save unconnected patches then prioritize the poor scoring ones

Habitat Patch resilience			
Metric	Description	Justification	Action if identified as the failing
Patch size	Area of each habitat patch (ha)	Larger patches can be considered more resilient. *This can be measured against threshold area values for species or species groups.*	Increase size of the patch by restoration or creation on adjacent land
Shape index	The relationship between habitat patch perimeter and area.	A score of 1 would represent a circle; scores below 1 represent increasingly complex or convoluted shapes. More compact shapes are considered more resilient (Lawton et al, 2010)	Habitat creation on adjacent land or promote land management practices that have a reduced impact on the habitat patches in the ecological network

Naturalness	The proportion of natural land cover around each patch within a dispersal distance scale buffer (500m).	Unnatural habitat was defined as urban or intensive agricultural land (land with permeability of 20 – 50). Patches with a greater proportion of natural habitat around them are considered to be more resilient.	Create and capitalise on opportunities within the same ecological network that will enable species movement. This can include promoting less intensive farming activities or more sensitive green space management in urban areas.
Edge naturalness	Similar to the above, this measures the proportion of natural land cover around a patch, but only within a 20m buffer, so as to take account of edge effects.	Negative edge effects are considered to be greatest if there is a higher proportion of unnatural land cover.	Habitat creation on adjacent land or promote land management practices that have a reduced impact on the habitat patches in the ecological network
Proportion designated or in conservation ownership	The amount of each habitat patch protected by a designation or conservation organisation ownership	Those patches with all or a high proportion of area covered by a designation or conservation ownership are considered to be more resilient. The designations considered were:, SSSIs, SPAs, SACs, LNRs, NNRs and Wildlife Trust, Woodland Trust, National Trust and Forestry commission ownership. LWS were not included as development can still occur on these sites.	-
Habitat resilience rank	Patch size score + Shape index score + Naturalness score + Edge naturalness score + Proportion within designation or conservation ownership score	Each habitat patch is assigned a 'Resilience Rank', with the highest scoring habitat patch assigned the best rank of 1	Depends on your focus but if you are looking to save the most vulnerable patches then prioritize the poor scoring ones

Network Coherence			
Metric	Description	Justification	Action if identified as the failing
Network Area	Size of each network (ha)	A larger network indicates better connected habitat	Check the Total area of core habitat per network metric to see whether the network is falling below critical thresholds
Proportion of core habitat per network	Percentage of each network made up of core habitat	This metric considers the relationship between the amount of habitat in a network and network size/landscape permeability. This metric can distinguish between networks that have the same area of core habitat but are different sizes because of the permeability of the surrounding landscape.	Check the Total area of core habitat per network metric to see whether the network is falling below critical thresholds

Sum of interconnectivity of core habitat	The sum of interconnectivity (number of habitat patches within a set buffer) for each habitat patch within a network	Networks containing habitat with high interconnectivity can be considered to have high coherence.	-
Sum of intra-connectivity per network	The area (ha) of each habitat patch within a network squared and summed per network.	This measure replaces simple metrics stating the number and size of habitat patches per network and represents a more meaningful relationship between the two. In this case a network with fewer, larger habitat patches would be considered more coherent than one with more, smaller patches.	-
Network coherence rank	(Network area score + Proportion of network made up by core habitat score + Sum of interconnectivity of core habitat per network score+ Intraconnectivity of core habitat per network score	Each network is given a 'Coherence Rank', with the highest scoring network assigned the best rank of 1	Depends on your focus but if you are looking to poorly connected networks then prioritize the poor scoring ones

Network Resilience			
Metric	Description	Justification	Action if identified as the failing
Total area of core habitat per network	Summed area of all core habitat patches within a network	This can be measured against threshold area values for species or species groups. Networks falling below the minimum threshold are considered not resilient as they will hold a smaller suit of species	Increase patch area with the network or number of (and therefore total area of) patches connected to the network
Network resilience rank	Average area weighted resilience score per network. The combined area weighted resilience score for each habitat patch averaged per network.	This represents the overall resilience of the habitat within each network and therefore the overall resilience of that network.	Depends on your focus but if you are looking to save the most vulnerable networks then prioritize the poor scoring ones

Woodland planting or expansion

The right tree in the right place for the right reasons - The Nature Recovery Network (NRN) can be used as a guide to indicate areas where woodland creation or expansion should have the most benefit for biodiversity. The NRN also excluded other priority habitat where we should not create woodland, such as species rich grassland, or other sensitive areas like heritage sites from the woodland network opportunities. However, it is only based on best available data which may be out of date in some cases – **always check the situation on the ground and seek advice from relevant experts.**

The NRN and Wetland opportunities layers illustrate the priorities for habitat restoration to make the networks more resilient. In high and medium priority areas the aim is to restore/create the network's core habitat type. In woodland terms this is seminatural broadleaved woodland of an appropriate species mix for the locality. The NRN is designed to prioritise restoration outwards from existing core habitat patches; expansion of woodland adjacent to existing semi-natural woodland enables not just the trees but the whole woodland community of ground flora, fungi, invertebrates etc. to establish more rapidly.

In low priority areas the aim is to increase the general permeability, of the wider landscape, to species movement. The NRN layer is a guide, it is generated from best available data and may not always reflect the true picture on the ground. Care should always be taken to prevent degradation or further isolation of any existing valued habitats. Where woodland and open habitat networks cross, wood pasture or traditional orchard planting may be a useful option as, if well managed, it should be permeable to both woodland and open habitat species. Woodland with large glades and rides is another possibility although management would need to be in place to keep the glades and rides open in the long term. Where wetland opportunities overlap with woodland opportunities, wet woodland might be a possibility.

Note that the woodland network has been modelled using woodland priority habitats as the Core Habitat. This means that other woodland (not of priority habitat type) is seen as a restoration opportunity within the model and therefore, even though it is already woodland, it may come under the high priority for woodland restoration/creation within the combined NRN map. Enhancements in such locations could involve improving the woodland physical structure and age structure through management, increasing the diversity of tree species, or restoring conifer plantations on ancient woodland sites to native broadleaved woodland.

Ecosystem services - While the NRN is specifically focused on restoring ecological networks based on outcomes for biodiversity, tree planting or other habitat creation can also benefit the delivery of other ecosystem services such as:

- carbon storage and sequestration.
- improvements in air quality where trees are planted in urban areas or along major roads.
- mitigate flood risk maintaining water quality as part of river catchment management slowing the flow of water across land to and preventing soil erosion.

- soil health by incorporating organic matter into the soil increasing soil infiltration and preventing soil erosion.
- local climate regulation and access to green space for people within urban areas.
- food provision – orchards and the potential of agroforestry to provide the benefits of trees hand in hand will agricultural food production.

The Gloucestershire LNP has also produced a Gloucestershire Tree Strategy https://www.gloucestershirenature.org.uk/glos-tree-strategy to guide and inform tree planting, growing and new woodland creation in Gloucestershire. Subjects such as planting versus natural regeneration are discussed within the document.