Local Nature Recovery Strategy for Cambridgeshire and Peterborough

Habitat Opportunity Modelling Methodology

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1. Habitat Basemap Methodology

1.1 Approach to mapping habitats

The first step was to produce a detailed map of the habitats present across Cambridgeshire and Peterborough. This is an important component of any assessment of natural capital assets and is required before an assessment of the current benefits and values being delivered by the natural capital, or opportunities for enhancement, can be determined. To do this, we used Ordnance Survey Mastermap polygons as the underlying mapping unit, and then a series of different data sets to classify each polygon to a detailed habitat type, and to associate a range of additional data (such as designations, public accessibility, elevation) with each polygon. The complete data that were used to classify habitats is shown in Box 1.

Box 1: Data used to classify habitats in the basemap:

- OS Mastermap Topography layer
- OS VectorMap District
- OS Open Greenspace data
- Open spaces (green infrastructure) data sets for each local authority area
- Priority habitats – supplied by The Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire (WTBCN)
- Natural England Priority Habitats Inventory
- Natural England statutory sites information (for SSSI, NNR, SAC, SPA and Ramsar)
- Local Wildlife Sites (LWS/CWS/PWS) and Protected Wildflower Verges datasets provided by WTBCN
- Habitat data provided by CPERC, Anglian Water, MKA Ecology, National Trust
- National Forest Inventory data
- Ancient Woodland Inventory data
- Crop Map of England (CROME)
- Built-up Area Boundaries data
- Digital terrain model
- Aerodromes from OpenStreetMap
- Rivers and chalk streams
- Local Nature Recovery Strategy data portal

Polygons were classified into Phase 1 habitat types and were also classified into broader habitat groups (such as BAP).

The habitat basemap consists of approximately 1.8 million polygon features.

Note that the basemap provides the best approximation of habitat types that can be achieved based on available data, and although carefully checked manually has not been ground-truthed and will inevitably contain errors. The supplied habitat data varies in age, with some more than a decade old, so some changes are inevitable and could only be partially checked. A particular challenge was classifying polygons where more than one habitat was present. Mixed habitats containing woodland and scrub, or grassland with woodland were classified in detail, but not all combinations of habitats could be accommodated. Other areas, where there was a mismatch between data sources, or land use is changing rapidly, remained a challenge.

2. Habitat Opportunity Modelling Methodology

The importance of landscape-scale conservation and ecological networks has become increasingly recognised over recent years. Many wildlife sites have become isolated in a landscape of unsuitable land uses and efforts are now being directed towards enlarging existing sites, linking existing habitat patches, and increasing connectivity, in line with the Lawton Principles. Species are more likely to survive in larger habitat networks, be able to move and colonise new sites, and are more resilient to climate change and other detrimental impacts.

Habitat opportunity mapping to enhance biodiversity follows this ethos by using ecological networks to identify potential areas for new habitats. Identified areas will be ecologically connected to existing habitats, thereby expanding the size of the existing network, increasing connectivity and resilience, and potentially increasing the ecological quality of the new site.

The approach used identifies three categories of opportunity, indicating three priority levels of importance for each habitat mapped (see section 1, habitat basemap methodology for details on how habitats were mapped). The broad habitats and their constituent types are shown below:

Broad habitat	Specific habitats included
Semi-natural grassland	Neutral, acid, calcareous, rough and semi-improved grasslands
Wet grassland	Marshy grassland, floodplain grazing marsh, lowland fen and swamp (reedbed)
Woodland	Broadleaved and mixed woodland types (excludes coniferous woodland, parkland or individual trees)

Biodiversity opportunity mapping followed a four-step process and was based on the approach developed by Catchpole (2006)[1] and Watts et al. (2010)[2].

[1] Catchpole, R.D.J. (2006). Planning for Biodiversity – opportunity mapping and habitat networks in practice: a technical guide. *English Nature Research Reports*, No 687

[2] Watts, K., Eycott, A.E., Handley, P., Ray, D., Humphrey, J.W. & Quine, C.P (2010). Targeting and evaluating biodiversity conservation action within fragmented landscapes: an approach based on generic focal species and least-cost networks. *Landscape Ecology,* 25: 1305–1318.

2.1 Four-step process

Step 1. Landscape permeability

This step involves assessing the permeability of the landscape to typical species from each habitat type and builds on work carried out by JNCC, Forest Research and others. Generic focal species are assessed for each habitat type as there is a lack of ecological knowledge to be able to repeat the process for multiple different individual species, and generic species provide an average assessment for species typical of each habitat type.

It is assumed that a species will have optimal dispersal capabilities in the habitat in which it is associated and hence the landscape is fully permeable if it consists only of this primary habitat. Each of the remaining habitat types is then assigned a permeability score that shows how likely and how far the species will travel through that habitat. Habitats are scored on a scale from 1 (most permeable) to 50 (least permeable). Permeability scores were based on expert scores compiled by JNCC. Once tables had been compiled showing permeability scores for each habitat, high (10m) resolution maps were then produced using bespoke modelling, showing the permeability of the landscape for generic species from each broad habitat type.

Step 2. Habitat networks

Step 2 uses the permeability map created above, along with information on average dispersal distances, to map which habitat patches are ecologically connected and which are ecologically isolated from each other. Dispersal distances were obtained from JNCC, which had performed a review of the scientific literature to ascertain the dispersal distances of a range of species for each habitat type. These were typically species of small mammals, smaller birds, butterflies, and plants. The average dispersal distance for each habitat is shown in the table below:

Dispersal distance in optimal habitat:	
Semi-natural grassland	2.0 km
Wet grassland & wetlands	2.0 km
Broadleaved and mixed woodland	3.0 km

Step 3. Identifying constraints

The habitat network map created in Step 2 can be used to indicate where new habitat could be created; any habitat created within the existing network would be ecologically connected to existing patches. However, in reality a number of constraints exist that need to be taken into account when producing opportunity maps. The aim of this step, therefore, is to produce a series of maps of constraints that can be used to show where habitat cannot or should not be created. The following constraints were mapped:

- Land-use constraints – infrastructure (roads, railways, and paths), urban (all buildings), gardens, and water (standing and running), as it is highly unlikely that these would be available for habitat creation.
- High quality habitats – habitats identified as being high quality, such as those identified by Natural England's Priority Habitat Inventory, as it would not make

sense to destroy existing high-quality habitat to create new habitat of a different type.

- Historic sites – data were obtained from Historic England on the location of Scheduled Monuments, Registered Parks and Gardens, and Registered Battlefields across the study area and a 30m buffer was applied around each individual site, as recommended by Historic England.
- National Grid gas pipelines, overhead lines and cables – data were obtained from the National Grid and a 10m buffer was applied around all features. This constraint was only applied when woodland opportunities were being mapped, as it would not be possible to plant trees in these areas, although grassland and wetland habitats would be feasible.
- For wet grassland and wetland habitats it was assumed that hydrology (wetness) would be a limiting factor. Therefore, habitat opportunity areas were restricted to areas within the indicative floodplain, as indicated by the Environment Agency's Flood Zone 2 map.
- Future development plans across Cambridgeshire and Peterborough such as the a428 road expansion and East West Rail line.
- Ministry of Defence (MOD) land.

Note that additional factors could be used as constraints, for example best and most versatile agricultural land (or the more stringent Grade 1 land). This was not applied as a constraint here as it would still be possible to create riparian buffer strips and similar small habitat enhancements in such areas, even if whole fields are not converted. Hence it was felt that agricultural land classification would work better as a factor to screen against when deciding on areas to take forward, rather than as a fixed constraint.

The constraints map was used to exclude areas that would be unsuitable or unavailable for new habitat.

Step 4. Habitat opportunity for biodiversity

In the next step, from the habitat opportunity map with constraints applied, two layers of habitat opportunity were then created:

- **Buffer** – areas that are immediately adjacent to existing habitat patches and will usually be the priority for habitat creation. The width of buffers was variable and a product of habitat patch size, distance to other habitat patches and the type of adjacent land use. By way of example, for a high-value grassland habitat patch, a wider buffer would be identified if the adjacent land use was more permeable for grassland species (e.g. species-poor grassland or wetland) than where the adjacent land use was less permeable (e.g. arable land).
- **Stepping stone** – areas that are slightly further away from existing habitats, but are close enough to be ecologically connected, and could potentially be

used to create stepping-stone habitats that could link up more distant habitat patches.

Three different priority levels are also identified:

- **Priority 1** – buffer and stepping stones close to existing nationally designated sites (e.g. SSSI's) or ancient woodland (for woodland opportunity map only).
- **Priority 2** – areas close to existing locally designated sites (either Local Nature Reserves or Local/County Wildlife sites).
- **Priority 3** – areas close to undesignated sites in the wider countryside

As the buffer and stepping stone areas identify portions of land in relation to the ecological network for each habitat, it often results in thin slivers of land being identified adjacent to existing habitats, which bear no relationship to existing fields and boundaries. As habitat creation or restoration projects usually operate on whole fields, an additional step was taken to identify those fields that present buffer and stepping stone opportunities.

As this approach to mapping identifies a significant proportion of the LNRS area as potential habitat creation opportunities, the decision was taken to reduce the opportunity areas to only include whole fields where over 25% of a parcel is selected as an opportunity buffer and the land parcels boundaries are known. This was later tested and further refined as part of the prioritisation process, so that a lower threshold of 10% was used within the priority natural landscapes in order to identify more land as opportunities in line with Lawton Principles.

A comparison of the networks and fields output is shown below:

3. Ecosystem Services Opportunity Methodology

3.1 Modelling and mapping ecosystem services (benefits)

Using a detailed habitat basemap, it is possible to quantify and map the benefits that these habitats (natural capital) provide to people. The ecosystem services mapped are shown in Box 1 below.

Box 1: Ecosystem services mapped

- **Carbon storage capacity** estimates the stock of carbon stored in each habitat type based on average values for vegetation and the first 30 cm of soil.
- **Carbon sequestration** calculates the amount of carbon taken up (sequestered) by trees and woodland each year, so is an annual flow of benefits (like the other ecosystem services below).
- **Air purification** (air quality regulation) estimates the relative ability of vegetation to trap airborne pollutants or ameliorate air pollution. Woodland habitats are by far the most effective habitat type at providing this service, but all woody habitats including hedgerows and scattered trees have some effect.
- **Noise regulation** is the capacity of the land to diffuse and absorb noise pollution. Complex vegetation cover, such as woodland, trees and scrub is considered to be most effective, and the effectiveness of vegetation increases with width.
- **Local climate regulation** estimates the capacity of an ecosystem to cool the local environment and cause a reduction in urban heat maxima. Natural vegetation, especially trees / woodland and water bodies, can have a moderating effect on local climate, making nearby areas cooler in summer and warmer in winter.
- **Pollination capacity** measures the capacity of the land to provide pollination services by estimating the probability that wild insect pollinators will visit.
- **Water flow regulation** is the capacity of the land to slow water runoff and thereby potentially reduce flood risk downstream.
- **Water quality (soil erosion) regulation** maps the risk of surface runoff becoming contaminated with high sediment loads before entering a watercourse, with a higher water quality capacity indicating that water is likely to be less contaminated. The model focuses on sedimentation risk from agricultural land, rather than urban diffuse pollution.
- **Food production** models the capacity of the land to produce food under current farming practices, based on habitat type and agricultural land classification.
- **Timber / wood fuel production** models the potential of trees and woodland to provide wood-based products, based on average yield.
- **Accessible nature capacity** maps the availability of natural areas and scores them by their perceived level of naturalness.

In most cases the models were applied at a 5m-by-5m resolution (with the exception of the pollination models and all demand models which were at 10m resolution) to provide fine scale mapping across the area. The models are based on the detailed habitat information determined in the basemap, together with a variety of other external data sets (e.g. digital terrain model, UK census data, open space data, and many other data sets and models). Note, however, that many of the models are indicative (showing that certain areas have higher capacity or demand than other areas) and in all cases the capacity and demand for Ecosystem Services is mapped relative to the values present within the study area.

More details on the mapping methodology for ecosystem services used for opportunities are shown below:

Water flow regulation capacity

A bespoke model was developed, building on an existing EcoServ R model and incorporating many of the features used in the Environment Agency's catchment runoff models used to identify areas suitable for natural flood management. Runoff was assessed based on the following three factors:

- **Roughness score** – Manning's Roughness Coefficient provides a score for each land use type based on how much the land use will slow overland flow.
- **Slope score** – based on a detailed digital terrain model, slope was re-classified into classes based on the British Land Capability Classification and others.
- **Standard % runoff** - was obtained from Hydrology of Soil Type (HOST) data. This was integrated with a layer showing impermeable areas where no soil was present (sealed surfaces, water and bare ground)

Each indicator was normalised from 0-1, then added together and projected on a 0 to 100 scale, as for the other ecosystem services. Note that this is an indicative map, showing areas that have generally high or low capacity and is not a hydrological model. High values (dark orange and red) indicate areas that have the highest capacity to slow water runoff.

Water quality regulation capacity

A modified EcoServ R model was developed, which combines a coarse and fine-scale assessment of pollutant risk.

At a coarse scale, catchment land use characteristics were used to determine the overall level of risk. The percentage cover of sealed surfaces and arable farmland in each sub-catchment (EA Waterbody catchment) was calculated and the values were re-classified into several risk classes. There is a strong link between the percentage cover of these land uses and pollution levels, with water quality particularly sensitive to the percentage of sealed surfaces in the catchment.

At a fine scale, a modification of the Universal Soil Loss Equation (USLE) was used to determine the rate of soil loss for each cell. This is based on the following three factors:

- **Distance to watercourse** – using a least cost distance analysis, taking topography into account.
- **Slope length** – using a flow accumulation grid and equations from the scientific literature. Longer slopes lead to greater amounts of runoff.
- **Land use erosion risk** – certain land uses have a higher susceptibility to erosion and standard risk factors were applied from the literature. Bare soil is particularly prone to erosion.
- **Watershed risk** – for each catchment area there is a score for the risk of pollution.

Each of the three fine scale indicators and the catchment-scale indicator were normalised from 0-1, then added together and projected on a 0 to 100 scale. As previously, this is an indicative map, showing areas that have generally high or low capacity and is not a process-based model. High values (red) indicate areas that have the greatest capacity to deliver high water quality (least sedimentation risk).

Air quality regulation capacity

Air purification capacity was mapped using an EcoServ R model. The model assigns a score to each habitat type, representing the relative capacity of each habitat to ameliorate air pollution. The cumulative score in a 20m and 100m radius around every 5m-by-5m pixel was then calculated and combined. The benefits of pollution reduction by trees and greenspace may continue for a distance beyond the greenspace boundary itself, with evidence that green area density within 100m can have a significant effect on air quality. Therefore, the model extends the effects of greenspace over the adjacent area, with the maximum distance of benefits set at 100m.

The final capacity score was calculated for every 5m-by-5m cell across the study area and was scaled on a 0 to 100 scale relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to trap airborne pollutants and ameliorate air pollution.

Accessible nature capacity

Accessible nature capacity was mapped using an EcoServ R model. In the first step, accessible areas are mapped. These are defined as:

- Areas 10m either side of linear routes such as Public Rights of Way, and pavements.
- Publicly accessible areas such as country parks, Countryside and Rights of Way Act (CRoW) access land, local nature reserves and accessible woodlands.
- Areas of green and blue infrastructure marked as accessible, including streams, reservoirs, canals, parks, playgrounds, and other amenity greenspaces.

These areas were then scored for their perceived level of naturalness, with scores taken from the scientific literature. Naturalness was scored in a 300m radius around each point, representing the visitors' experience within a short walk of each point. The resulting map shows accessible areas, with high values representing areas where habitats have a higher perceived naturalness score. Scores are on a 1 to 100 scale relative to values present within the study area. White space shows built areas or areas with no public access.

Larger continuous blocks of more natural habitat types will have higher scores than smaller isolated sites of the same habitat type. One consequence is that linear routes, such as footpaths, that pass through land with no other access will not score highly.

Noise regulation capacity

A modified EcoServ R noise regulation model was used. First, the capacity of the natural environment was mapped by assigning a noise regulation score to vegetation types based on height, density, permeability and year-round cover. Next, the noise absorption score in 30m and 100m radii around each point was modelled and the scores combined, which results in wider belts of vegetation receiving a higher score. The score was calculated for every 5m-by-5m cell across the study area and is scaled on a 0 to 100 scale, relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to absorb noise pollution.

Local climate regulation capacity

Local climate regulation capacity is mapped using an InVest model. Vegetation can help reduce the urban heat island by providing shade, modifying thermal properties of the urban fabric, and increasing cooling through evapotranspiration.

The model calculates an index of heat mitigation based on shade, evapotranspiration, and albedo, as well as distance from cooling islands (e.g. parks) for each pixel. The raster generated by this process shows the capacity of each land use to cool the air and is calculated relative to the average temperature across the summer months.

The temperatures recorded in each location will differ from the index shown here since land use would generate a given temperature which in reality is blended with the temperatures generated by the landcover of the surroundings.

Scores are on a 1 to 100 scale, relative to values present within the study area. To retain consistency with the other models, high values (red) indicate areas that have the highest capacity for local climate regulation as a service, so are actually areas that are cooler.

3.2 Ecosystem service opportunity maps

Ecosystem services opportunity mapping is a Geographic Information System (GIS) based approach used to identify potential areas for the expansion of key habitats to meet different objectives, whilst taking constraints into account. Opportunities have been mapped to:

- reduce surface water runoff (and hence flood risk),
- reduce soil erosion and improve water quality,
- ameliorate air pollution
- enhance public access to natural greenspace,
- reduce noise pollution

- reduce urban heat

The opportunity maps update and build on those produced in the Modelling and mapping ecosystem services (benefits) section. The opportunities highlight the top 10%, 10-25% and 25-50% of sites for each respective service, indicating three levels of importance, based on the ecosystem services maps. Constrained areas are excluded and, as for the habitat opportunity outputs (see section 3, habitat opportunity methodology), consisted of existing buildings, infrastructure, gardens and water, existing areas of high-quality habitats, and listed heritage assets. Initial opportunity layers were converted into field-scale maps.

The water flow regulation opportunity map identified areas where runoff is currently high and could be reduced through changing land use or habitats. The greatest number and highest priority opportunities generally corresponded to areas with relatively steeper slopes. Areas of bare soils, such as quarries and mineral extraction sites, are also highlighted as priorities throughout the study area.

The water quality regulation opportunity map focussed of areas where soil erosion is currently high and could be reduced through habitat change. To further prioritise the opportunity areas identified, we gathered information on the overall waterbody status from the Water Framework Directive, for each river waterbody catchment. This data was used to weight the opportunity map, with catchments with worse water quality given greater weighting. Opportunities are focussed close to watercourses and especially on arable land, which is a significant source of soil erosion.

The air pollution opportunity map is demand led, so areas highlighted are those with the highest demand, but currently low supply of the service. This tends to be urban areas close to main roads, with no existing tree cover.

The accessible natural greenspace opportunity map also focussed on areas with the highest demand, where supply was low. The best opportunities for increasing access to the natural environment were concentrated around the edges of the urban areas, often in rings around the edges of settlements.

Combined ecosystem opportunity maps (delivering multifunctional benefits)

In addition to mapping the individual opportunities, it is also possible to examine multiple opportunities, which are areas where new habitat can be created that provides opportunities to enhance more than one of the services mapped previously. These are areas that could deliver multifunctional outcomes. This is assessed by overlaying individual opportunity maps to determine the degree of overlap, examining each of the main habitat types in turn. Here, if an opportunity falls within the top 10% (highest) opportunity it is given a score of 3, an opportunity in the 10-25% (high) zone is given a score of 2, and an opportunity in the 25-50% (medium) zone is given a score of 1.

Biodiversity opportunities can score between 1 and 3, with the highest priority score taking precedence where there is more than one opportunity in the same location[3].

The maps can be combined in a variety of ways, depending on the objective. When biodiversity enhancement is the primary objective, as is the case for the LNRS, we have restricted combined opportunities to areas that present a biodiversity opportunity. Hence opportunity areas are only included for locations that are ecologically connected to existing habitats. This follows the ethos of the LNRS process, with the focus on enhancing biodiversity first, with environmental benefits and co-benefits as additional features that can be used to prioritise between opportunity areas for biodiversity.

The final opportunity maps thereby combine the woodland, grassland and wetland habitat opportunity maps with their ecosystem benefits and identify all potential opportunities within the LNRS area.

[3] Note that for broadleaved woodland, all four ecosystem services maps are combined, along with the woodland biodiversity opportunity map (each scored out of 3), so the combined opportunity score is out of a theoretical total of 15. For semi-natural grassland and wet grasslands and wetlands, air quality regulation opportunity areas are not included as these habitats will not significantly improve the provision of this service, hence the combined score is out of a theoretical total of 12.