Nature network mapping

The Challenge: to identify the most important areas of mainland Cornwall for biodiversity and the provision of ecosystem services that are currently excluded from any statutory protection.

What does the map show? The nature network map identifies the most valuable 20% of mainland Cornwall not currently subject to statutory protection. The area is sub-divided into three exclusive bands representing the most valued 5%, 5-10% and 10-20% of unprotected areas.

Intended uses: The map is intended to inform a range of strategic planning application such as:

- the expansion of the existing network of protected areas;
- the strategic targeting of resources to protect biodiversity and ecosystem services;
- identification of key areas where future change in land use or development risks a strategic loss of biodiversity or ecosystem service provision.

Notes on the use and interpretation of the nature network map:

- The spatial unit of prioritization is 100 square metre cells although some finer resolution features are accounted for (such as ancient and venerable trees).
- Existing protected areas (irrespective of their condition) are assumed to be preserved and maintained. Their presence informs the prioritization of non-protected areas.
- Cell rankings are dependent upon maintaining the landcover and existing services of more highly ranked cells. This dependence is most evident by considering how the value of a habitat 'corridor' is only meaningful if the two habitats that it links are maintained.
- Rankings are assigned uniquely on the basis of *current* land cover and the maps are not suitable for use in future scenarios.
- The exclusion of an area from the top 20% of cells dose *not* imply that the area lacks any strategic biodiversity value or service provision.
- Similarly, a high ranking does not necessarily imply that the biodiversity or services provided cannot be augmented by changes to management, land cover or use.

Method of spatial prioritization

The mapping is produced using the Zonation model of spatial prioritization (Lehtomäki *et al.* 2016), which has been widely used for the identification of new protected areas or conservation zones, and the expansion of existing networks. The approach requires data and expert judgement concerning, for example, the relative importance of different land features and habitats.
Inevitably mapping is constrained by the data and information that is available. The method does not pretend to capture every possible factor that might inform the relative importance of areas. The method focuses on key factors that (i) we believe should inform spatial prioritization and (ii) for which there is sufficiently reliable information available.
It is important to recognize that the data informing this prioritization is not comprehensive. Nevertheless, use of the model and its outputs provides an improvement on *ad hoc* decisions that do not exploit the available evidence and data concerning the state of the natural environment in Cornwall. Basing decisions on the Zonation prioritization should not be considered sufficient, but can contribute to more informed decision-making.
The approach allows easy updating or replacement of source data layers, adjustments to the perceived importance of different services, and can be applied to different spatial areas and scales.

Feature weighting

The relative importance of different habitats and features informing the prioritization is determined by assigning weights. Positive weights describe the relative value or benefits of different services and features. Negative weights indicate a constraint or cost of realising benefits. Weightings vary from -3 to +5. Full weightings are provided in Table **.
The dominant land cover/habitat of an area is determinant of both of the biodiversity potential of an area and its capacity to deliver ecosystem services.

Landcover weightings: were attributed according to a judgment of their capacity to support biodiversity. In addition, the dominant landcover is often determinant of the capacity of an area to deliver many ecosystem services (accounted for separately).
The following general weightings were used for the exclusive landcover/habitat categories:

- BAP priority habitats: +2
- Other semi-natural habitats: +1
- Urban, arable and improved grassland: 0

In effect therefore approximately 77% of mainland Cornwall is attributed a zero weighting in terms of its dominant landcover type.

Land features: features providing additional habitats such as hedgerows or open waterways were given a 0 to +2 weighting dependent upon length and/or quality of the feature.

Habitat designations: land designations relating to biodiversity were used as strong indicators of the biodiversity value of areas, whether these were statutory

protections (e.g. SSSIs) or other designations such as County wildlife sites or ancient woodland. Weightings varied from +1 to +5.

Ecosystem services: were weighted between +1 and +5 according to a judgement of the relative importance of the service and confidence in its estimation. Service layers were calculated on the basis of existing demands such as current sources of drinking water, location of aquaculture or buildings at risk of flooding.

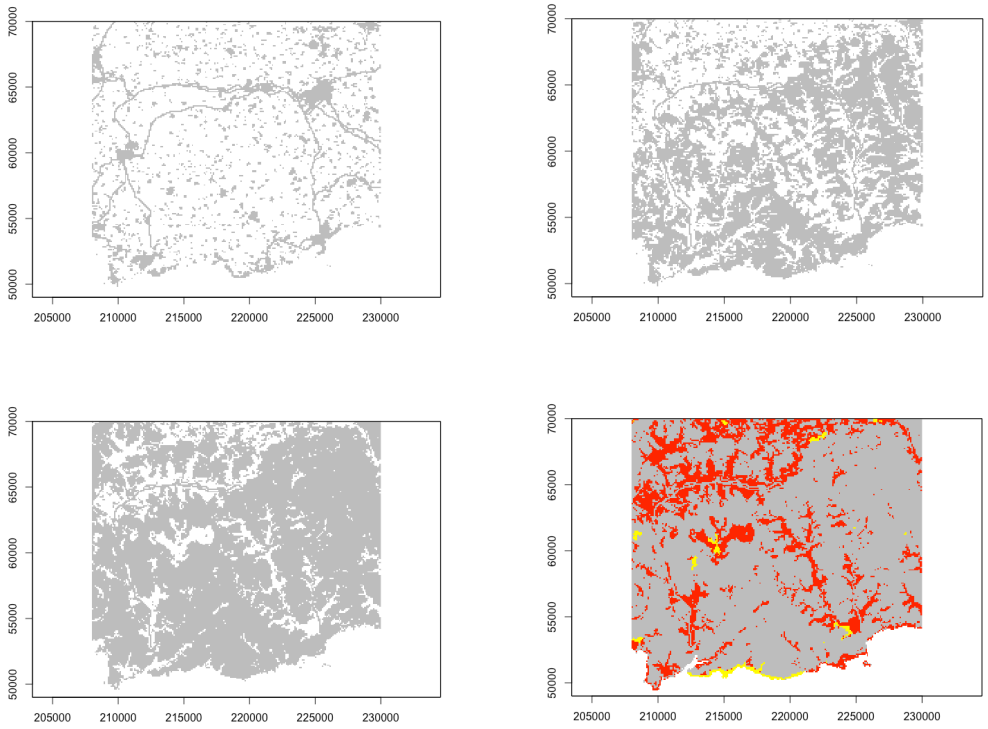
Constraints and opportunity costs: opportunity costs have not been included as doing so would result in a prioritization that maximises the difference between costs and benefits, rather than one seeking to maximise ecological or biodiversity benefits which is the primary intension of the nature network map. Nevertheless, a negative weighting has been applied to certain land features likely to reduce the potential biodiversity or other benefits of a cell including:

- man-made infrastructure, such as main roads and railways;
- the percentage of an area that is covered with buildings;
- certain recreational uses such as golf courses;
- china clay extraction areas.

Cell removal iteration

The spatial prioritization works by iteratively removing the least 'valuable', lowest ranked cells (see figure *) on the basis of:

- Weighted fraction of all remaining features that values cells containing a high overall proportion of individual features (*ie* it will most value cells containing a high proportion of a habitat type or service).
- An 'added benefit function' that sums the normalised distribution across all features and so tends to remove cells with low feature diversity before cells with higher feature diversity, such as cells providing *both* valuable habitat *and* ecosystem services.
- Aggregation of protected areas – a 'boundary length penalty' seeks to reduce edge to area ratio of *all* remaining cells (irrespective of the type of features within those cells). In effect this will aggregate and connect together protected areas rather than specific habitat types.
- Existing protected areas are designated as the last areas to be removed, ensuring that they inform the ranking of all other areas.



Figures * show the iterative 'removal' in grey of the least valued or lowest ranked (i) 20% (predominantly urban and infrastructure areas), (ii) 60% and (iii) 80% of cells for the Fowey valley region, the remaining cells shown in (iv) corresponding to the highest 20% of ranked cells (red) and areas under statutory protection (yellow).

Issues and Considerations

Vulnerability and ranking: the most highly ranked cells are assigned to areas supporting biodiversity and delivering ecosystem services. It is important to note that these do *not* equate to the most vulnerable habitats. The lack of opportunity costs in the prioritization method means that pressures associated with alternative land uses are not accounted for.
For example, it could be argued that many areas of moorland are less vulnerable than habitats around urban centres or more agriculturally productive land as the pressures for development will be greatest for these latter areas.

Valuing urban and agricultural land - currently all cells with a dominant land cover that is urban, suburban, arable or improved grassland are given a zero weighting. In effect these land cover types are unlikely to be heavily represented in the proposed nature network but are not excluded *a priori*. Such land cover types may be valued due to the presence of other positively weighted features, such as hedgerows and rivers.
We recognize that the biodiversity potential of urban and agricultural land is very variable. Urban and suburban areas often have the capacity to support higher levels of biodiversity than many arable and improved grassland landscapes. Equally however, methods of land management of rural environments have significant implications for their biodiversity value. How

these areas are best represented within the spatial prioritization model should reflect the policy applications of the nature network mapping. Currently, for example, the zero weighting applied to most agricultural and urban areas does not imply they lack any biodiversity value, but that such value is unlikely to change if these areas do not receive any additional protection, or that their value depends on policies or management options that are unaffected (or not targeted) by the nature network mapping.

References

Lehtomäki J, Moilanen A, Toivonen T Leathwick J 2016. Running a Zonation planning project. Unigrafia, Helsinki. ISBN: 978-951-51-1923-0 (PDF).

Moilanen A, Pouzols FM, Meller L, Veach V, Arponen A, Leppanen J, Kujala H 2014 Zonation - Spatial conservation planning methods and software. Version 4. User Manual. University of Helsinki, Helsinki.

Moilanen, A. 2013. Planning impact avoidance and biodiversity offsetting using software for spatial conservation prioritization. Wildlife Research, 40: 153-162.

Joona Lehtomaki J, Tomppo E, Kuokkanen P, Hanski I, Moilanen A 2009 Applying spatial conservation prioritization software and high-resolution GIS data to a national-scale study in forest conservation. Forest Ecology and Management 258, 2439–2449

Datasets and resources used

The type of data used for the spatial prioritization included

- Mutually exclusive presence / absence data, such as the main habitat or land cover types.
- Non-exclusive presence / absence data that might be combined with other habitat types, such as the presence of open rivers or main roads
- Non-exclusive scaled quantitative data that provided an indication of the relative importance of different features (for example hedgerow lengths) or service provision (quantified estimates of ecosystem services).

Land cover and habitat type

Landcover types were derived from a compilation of several landcover data sources. Each cell was attributed to a single landcover type derived from these classifications (ie exclusive categorization).

LANDCOVER & HABITATS TYPE DATA			
Data source	Data owner	Source link	Usage Notes
Land cover map 2015 v1.2 (2017)	CEH	https://eip.ceh.ac.uk/lcm/lcmdata	
Corine LC2012	EU	http://land.copernicus.eu/pan-european/corine-land-cover	Only used for validating other types and comparison
Priority habitat inventory	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/priority-habitat-inventory-england-south	Compilation of BAP priority habitats
National forest inventory	FC	https://data.gov.uk/dataset/national-forest-inventory-woodland-england-2015	Largely based on satellite imagery up to 3 yrs old. Woodland categorization only.
Plymouth Coastal Observatory habitat data.	PCO	http://southwest.coastalmonitoring.org/data-types/habitat-mapping/	Coastal landcover data
Open mosaic on previously developed land	NE & Buglife	https://data.gov.uk/dataset/8509c11a-de20-42e8-9ce4-b47e0ba47481/open-mosaic-habitat-draft	DRAFT data
Woodland pasture and parkland	NE	https://data.gov.uk/dataset/61e6f611-af12-471e-8732-76b4d66dbb1f/wood-pasture-and-parkland-bap-priority-habitat-inventory-for-england	Recent addition to priority habitats

Species presence data

Point data of species observations or recordings have **not** been used in the analysis. It was considered that the observational records showed high spatial bias resulting from the very uneven recording effort across the county. In the

future it may be possible to use such point information to inform models of a species distribution that in turn could be used for spatial prioritization.

Habitat features

In addition to land cover data describing cell habitat types, additional data on habitat features contained within cells was also used. These included linear and point features, such as open river, hedgerows, and the presence of ancient and venerable trees. Such data was non-exclusive (a cell could contain several features of the same or different types) and could be recorded as the presence/absence of a feature (such as a river bank) or scaled according to a measure of the abundance of a feature, such as the total length of hedgerows within a cell or number of recorded ancient/venerable trees.

HABITAT & LANDCOVER FEATURES			
Data source	Data owner	Source link and reference	Usage Notes
OS Open Rivers	OS	https://www.ordnancesurvey.co.uk/opendatadownload/products.html	
Open Greenspace	OS	https://www.ordnancesurvey.co.uk/opendatadownload/products.html	golf courses & playing fields
Hedges	ERCCIS	ERCCIS Hedges and Field Boundaries Project hedges layer: erccis@cornwallwildlifetrust.org.uk	
Ancient Tree Inventory	Woodland Trust	https://ati.woodlandtrust.org.uk	
Priority habitats inventory	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/priority-habitat-inventory-england-south	No main habitat category

Habitat and biodiversity designations

A range of statutory and non-statutory designations, primarily derived from the biodiversity richness of an area, were used as further indicators of biodiversity. These designations are generally non-exclusive, and the same areas can be classified under several different designations. For example, many SSSI areas were also designated as SAC or SPA areas. Undue bias towards multiple-designated areas was prevented by either suitable weighting scores or by creating synthesis layers brining together several different designations. Statutory designated areas were defined as all areas designated as SSSI, SAC, SPA, national or local nature reserves.

HABITAT & BIODIVERSITY DESIGNATIONS			
Data source	Data owner	Source link and reference	Usage Notes
Ancient woodlands	NE	https://data.gov.uk/dataset/9461f463-c363-4309-ae77-fdcd7e9df7d3/ancient-woodlands-england	
County wildlife sites	ERCCIS	https://erccis.org.uk/CountySites	
AONB (2018)	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/areas-of-outstanding-natural-beauty-england	
SSSI (2018)	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/sites-of-special-	

		scientific-interest-england	
SPA (2018)	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/special-protection-areas-england	
SAC (2018)	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/special-areas-of-conservation-england	
National Nature Reserves (2018)	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/national-nature-reserves-england	
Local Nature Reserves (2018)	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/local-nature-reserves-england	
Important Plant Areas	Plantlife	http://www.plantlifeipa.org/home	
RSPB reserves	RSPB	https://www.arcgis.com/home/item.html?id=6076715cb76d4c388fa38b87db7d9d24	

Additional habitat condition and quality indicators

Very little spatial data is available on the current condition of habitats in Cornwall. Where available, catchment ecological quality data was used as indicators of aquatic habitat condition and SSSI condition data was used as indicator of habitat condition within those sites. Areas participating in Higher level or Organic countryside stewardship schemes were also considered indicative of good condition of arable and grassland areas.

HABITAT CONDITION INDICATORS			
Data source	Data owner	Source link and reference	Usage Notes
SSSI (2018)	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/sites-of-special-scientific-interest-england	SSSI habitat condition
WFD Catchment data	EA	https://environment.data.gov.uk/catchment-planning/ui/reference	Aquatic habitat condition.
Countryside stewardship participation	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/countryside-stewardship-scheme-2016-management-areas-england	Higher and Organic level only

Ecosystem service benefits

A comprehensive list of data sources used in the calculation of ecosystem services is detailed under their individual methodologies.

No ecosystem services dependent upon public access to the land (*eg* recreation, tourism, health benefits) or

ECOSYSTEM SERVICE	
Service	Description
Flood mitigation	Mitigation of flood surface water and river/sea flood risk on downstream potential vulnerable populated areas
Aquaculture water quality	Mitigation of water pollution upstream of major aquaculture sites

Drinking water quality	Mitigation of water pollution in drinking water sensitive areas
Bathing water quality	Mitigation of water pollution upstream of beaches
Soil loss mitigation	Mitigation of soil loss risk derived from ESDAC soil erosion by water estimates: https://esdac.jrc.ec.europa.eu/content/soil-erosion-water-rusle2015)
Soil carbon	Soil carbon stock in top 30cm from National Soil Map www.landis.org.uk/data/natmap.cfm
Pollination	Pollinator friendly habitats close to agricultural arable areas.
Air quality mitigation	Mitigation of landcover in air quality monitoring zones

Facilitating factors & other non-biodiversity benefits

Data sources were used to identify key factors that could restrict alternative uses (reduce opportunity costs) or bring additional non-biodiversity benefits, such as sites of geological or heritage value. These layers might be considered facilitating factors that would help realise biodiversity benefits and/or reduce opportunity costs as they restrict alternative land uses. Additional factors that could be considered include:

- Additional indicators of sympathetic land ownership or management.
- Unsuitability for alternative land uses including topography such as steep slopes, aspect, elevation and wind exposure.

FACILITATING FACTORS & DESIGNATIONS			
Data source	Data owner	Source link and reference	Usage Notes
County geology sites	ERCCIS	https://erccis.org.uk/DataHoldings	Not used
World Heritage Site	EH	https://data.gov.uk/dataset/3ac5c299-6805-476b-af9b-90aadec5e7b4/world-heritage-sites-gis-data	Not used
Heritage coast	NE	https://naturalengland-defra.opendata.arcgis.com/datasets/heritage-coasts-england	Not used
Scheduled monuments	EH	https://historicengland.org.uk/listing/the-list/data-downloads/	Not used
Battlefields	EH	https://historicengland.org.uk/listing/the-list/data-downloads/	Not used
Doorstep greens	NE	https://data.gov.uk/dataset/6a80e5a7-017e-49ba-a981-5cd0c727086f/doorstep-greens-polygons	

Constraints and Costs

Factors that could restrict the potential biodiversity value or impede the protection of sites can be attributed a negative weighting. These can include existing infrastructure and/or buildings, future planning commitments, certain kinds of recreational use (golf courses, playing fields) or suitability for alternative land use such as the agricultural land grade.

HABITAT CONDITION INDICATORS			
Data source	Data owner	Source link and reference	Usage Notes
Agricultural land classification	NE	http://naturalengland-defra.opendata.arcgis.com/datasets/agricultural-land-classification-alc-grades-post-1988-survey-	Not used

		polygons-england	
OS Open Map Local Vector	OS	https://www.ordnancesurvey.co.uk/opendatadownload/products.html	Rail network and % built-up area
OS Open Roads Vector	OS	https://www.ordnancesurvey.co.uk/opendatadownload/products.html	Road network and type
China clay pits	OSM	https://www.openstreetmap.org/#map=6/54.910/-3.432	Complemented by aerial photography and remote sensing data
Allocation areas	CC		

Feature layers and weightings used by Zonation

Dominant landcover type	Type of data	Weighting
Coniferous woodland	Presence / Absence	1
Deciduous woodland	Presence / Absence	2
Scrub and other woodland	Presence / Absence	1
Traditional orchard	Presence / Absence	2
Woodland pasture	Presence / Absence	2
Seminatural grassland	Presence / Absence	1
Acid grassland	Presence / Absence	1
Lowland dry acid grassland	Presence / Absence	2
Calcareous grassland	Presence / Absence	2
Neutral grassland	Presence / Absence	1
Meadows upland and lowland	Presence / Absence	2
Grazing marsh pasture	Presence / Absence	2
Maritime grassland	Presence / Absence	1
Fen Marsh	Presence / Absence	1
Reedbeds	Presence / Absence	2
Fens upland and lowland	Presence / Absence	2
Purple moor grass	Presence / Absence	2
Dwarf Shrub Heath Bog	Presence / Absence	1
Blanket bog	Presence / Absence	2
Bracken	Presence / Absence	1
Heathland upland and lowland	Presence / Absence	2
Inland rock	Presence / Absence	1
Calaminarian grassland	Presence / Absence	2
Quarry	Presence / Absence	1
Open mosaic	Presence / Absence	1
Supralittoral rock	Presence / Absence	1
Maritime cliff and slope	Presence / Absence	2
Littoral rock priority	Presence / Absence	2
Littoral rock	Presence / Absence	1
Supralittoral sediment	Presence / Absence	1
Coastal sand dunes	Presence / Absence	2
Coastal vegetated shingle	Presence / Absence	2
Littoral sediment	Presence / Absence	1
Saltmarsh	Presence / Absence	2
Intertidal mudflats	Presence / Absence	2
Sheltered muddy gravels	Presence / Absence	2
Blue mussel beds	Presence / Absence	2
Saltwater	Presence / Absence	1
Saline lagoons	Presence / Absence	2
Freshwater	Presence / Absence	1

River or stream	Presence / Absence	2
Standing freshwater	Presence / Absence	1
Arable	Presence / Absence	0
Improved grassland	Presence / Absence	0
Builtup	Presence / Absence	0
Suburban	Presence / Absence	0
Urban	Presence / Absence	0
Land features / linear habitats	**Type of data**	**Weighting**
Hedges	Total length	2
Open rivers	Presence / Absence	1
A roads	Presence / Absence	-1
B roads	Presence / Absence	0
Dual carriageway roads	Presence / Absence	0
Minor roads	Presence / Absence	0
Railways	Presence / Absence	-1
Building cover percentage	Scaled 0:100	-5
Doorstep greens	Presence / Absence	0
Parks and Gardens	Presence / Absence	0
Golf courses	Presence / Absence	-1
Playing field	Presence / Absence	-1
China claypit area	Presence / Absence	-5
Biodiversity designations	**Type of data**	**Weighting**
Ancient woodlands	Presence / Absence	5
High level stewardship	Presence / Absence	0
Organic stewardship	Presence / Absence	0
Plantlife designated area	Presence / Absence	5
RSPB reserve	Presence / Absence	5
County wildlife site	Presence / Absence	3
Non-dominant priority habitats	Presence / Absence	1
Any statutory protected areas (SSSI, SPA, SAC, national or local nature reserve)	Presence / Absence	5
AONB	Presence / Absence	0
World heritage area	Presence / Absence	0
Heritage coast	Presence / Absence	0
Allocation zones	Presence / Absence	0
Ecosystem Services	**Type of data**	**Weighting**
Water quality service for aquaculture	Scaled 0:100	1
Water quality service for bathing waters	Scaled 0:100	1
Water quality service for drinking water	Scaled 0:100	1
Water quality service for other	Scaled 0:100	0

catchments		
Flood mitigation service	Scaled 0:100	2
Pollination service	Scaled 0:100	1
Soil loss mitigation service	Scaled 0:100	1
Soil carbon stock (top layer)	Scaled 0:100	1
Air pollution mitigation service	Scaled 0:100	1
Topography	**Type of data**	**Weighting**
Elevation	Metres elevation	0
North facing aspect	Presence / Absence	0
South facing aspect	Presence / Absence	0
Medium slope	Presence / Absence	0
Steep slope	Presence / Absence	0
Soil	**Type of data**	**Weighting**
High peat content soil	Presence / Absence	0
Agricultural grade 1 land	Presence / Absence	0
Agricultural grade 2 land	Presence / Absence	0
Agricultural grade 3 land	Presence / Absence	0
Agricultural grade 4 land	Presence / Absence	0
Agricultural grade 5 land	Presence / Absence	0
Heritage	**Type of data**	**Weighting**
Battlefield	Presence / Absence	0
Scheduled monument	Presence / Absence	0
Heritage coast	Presence / Absence	0