**Present**

* If current records, within last 3 years, PRESENT is applied
* If current uncertain records eg potential breeder or 1 individual seen PRESENT is applied to *most likely* and *upper bound,* ABSENT applied to *lower bound*
* If records of breeding from last decade (eg from National surveys between 2008-2011) but no additional records from subsequent surveys PRESENT is only assigned to *upper bound*.

**Viability**:

For rare breeding birds **work flow 1:**

* If below 15 breeding pairs consider as **not** viable (PRESENT) for *lower* and *most likely* bound, this is a national level application of IUCN Red List Criteria D to account for very small population sizes. It accounts for small but increasing populations that are still be threatened with stochasticity e.g persecution or bad winters. VIABLE applied to *upper bound.*
* Calculate recent (3 generations) population trend in spatial unit
  + , aligning with IUCN Red List criteria C1
* If less than 3 generations trend, calculate 2 generations. If decline >20% then endangered by IUCN Red List guidelines C1 and assigned PRESENT
* If low survey power/not well studied species VIABLE may be assigned *upper bound* to account for uncertainty
* If less than 2 generations and >25% decline in 1 generation assign as above: PRESENT (and VIABLE *upper bound* if large uncertainty by low survey/recording ability)
  + If a large increase within last 3 generations then *most likely* to be VIABLE, not functional (on a current baseline) as would expect to see "packing" at carrying capacity. FUNCTIONAL could be considered for *upper bound* (see functionality calculation)

For birds without population trends (non-rare breeding birds) **Work flow 2**

* + Use BTO Breeding Bird Survey data (BBS)
    - Many have country trends (eg Wales, Scotland, Northen Ireland which are all distinct spatial units) for the last 27 years
    - Some have England regional trends for last 27 years, can be used as a "3 generation trend"
      * For birds where 27 years is over 3 generations this adds uncertainty, but overall we would expect an increase from recent DDT low point (1970’s). As there are no identified new threats in the last 25 years, we would expect these trends to be increasing, showing a useful population trend
  + Then as above:
    - If >10% decrease assign PRESENT , aligning with IUCN Red List criteria C1
* If less than 3 generations in 27 years and instead 2 generations, then decline >20% then endangered by IUCN Red List guidelines C1 and assigned PRESENT
* If low survey power/not well studied species VIABLE may be assigned *upper bound* to account for uncertainty
* If less than 2 generations and >25% decline in 1 generation assign as above: PRESENT (and VIABLE *upper bound* if large uncertainty by low survey/recording ability)

For birds with no or highly uncertain BBS data **Workflow 3**

* + Consider local raptor monitoring and reporting groups
    - Look at yearly reports and compare across 3 generations (or as close as possible if data not available) if population declines >10% non viable (PRESENT)
      * Caveats that data can be questionable and need interrogation to be used (will only need to be used for minimal number of species)
* If data has associated uncertainty and small declines between 10-20% population decline, VIABLE could be assigned *upper bound* to convey uncertainty
* Compare distribution to available habitat suitability maps and species specific charity recording schemes (eg The Barn Owl Trust)
  + - Some raptor reports have "expert " elicitation or comments from regional raptor groups, this can be used to determine population trends in an area and extrapolate for spatial unit

**Functionality:**

* Only considered for increasing or stable populations, or population with initial stability and very small declines <10%.
* Looking at trends across 3 generations- if increasing overall consider county level changes, if decreases in 50% of either:
  + Number of counties it inhabits (eg declining in 3 of 5 counties in SU)
  + Or total population number such as:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year | County 1 | County 2 | County 3 | total |
| 3 gen ago | 89 | 34 | 20 | 143 |
| present | 31 | 60 | 55 | 146 |

* + - Overall increase from 143->146,BUT decline in county 1, which held over 50% of population 3 gen ago
  + Therefore not functional, despite overall increase, *upper bound* and *most likely* bound assigned VIABLE
* For specialists:
  + Calculate current carrying capacity (CCC) of habitat using method in R
    - Using CORINE land map establish area of currently available habitat for habitat specialists.
    - From literature search divide this available habitat by territory size. This produces an expected density of breeding pairs. See supplementary data for code.
      * Sense checking showed this method consistently under predicted numbers of Goshawks (*Accipiter gentilis*) therefore:
        + If number of breeding pairs recorded is below half of the CCC considered non-functional VIABLE assigned *Upper bound* and *most likely*
        + If above half of CCC may be functional in current conditions, must now compare to *benchmark* habitat (see below).
* For generalists and specialists considering functionality at benchmark year:
  + - * Consider land available at set benchmark year of 1750. If over 50% of this land has been lost since 1750 then not functional *upper bound* is assigned VIABLE
      * If modified land is still able to be inhabited but at lower numbers or is negatively impacted by land changes then still non functional.
    - Using HYDE maps to calculate change in habitat:
      * Set a baseline of land use change of 1750- the same across all species (caveats discussed in limitations)
      * Using HYDE database ([Hyde Portal](https://hyde-portal.geo.uu.nl/portal)) taking screen captures of Maps for four conditions: urban area, cropland, pasture, grazing land at 1750 and 2021
      * Such as:
      * A map of united kingdom

        AI-generated content may be incorrect.
      * Which shows pasture from 1750.
      * Colour determined by the proportion of pasture (or another factor) in each square.
      * Then complete a comparison to 2021 land use: (as this is the most recent bird data)

A map of the united kingdom

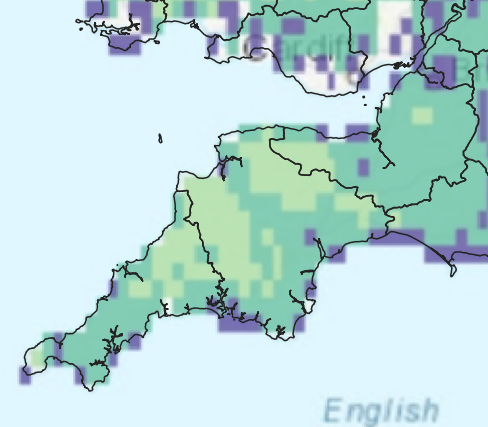
AI-generated content may be incorrect.

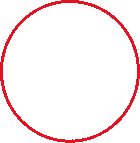
* + - * Pasture 2021
      * Cells are approximately 9.27x9.27km and scale is from 0-70km^2. Raw values cannot be extracted, but midpoints of each discrete colour code are taken:

A colorful striped banner

AI-generated content may be incorrect.

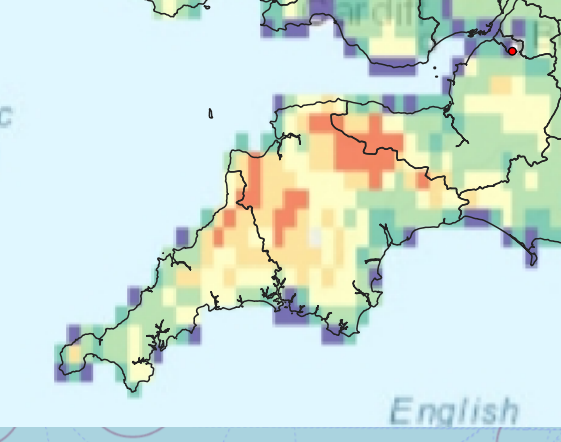
|  |  |  |
| --- | --- | --- |
| Colour | Range (r) km^2 per cell | Midpoint (2dp) |
|  | 61.25 ≥ r < 70.00 | 65.63 |
|  | 52.50 ≥ r < 61.25 | 56.88 |
|  | 43.75 ≥ r < 52.50 | 48.13 |
| A colorful striped banner  AI-generated content may be incorrect. | 35.00 ≥ r < 43.75 | 39.38 |
|  | 26.25 ≥ r < 35.00 | 30.63 |
|  | 17.50 ≥ r < 26.25 | 21.88 |
|  | 8.75 ≥ r < 17.50 | 13.13 |
|  | 0 > r < 8.75 | 4.38 |

* Then a proportion of each colour is estimated in 10% bins for each county, eg 1-10%, 11-20%…. 91-100%.
* Such that for Devon (middle county circled in red):



|  |  |  |
| --- | --- | --- |
| Colour | Midpoint (2dp) km^2 of pasture per cell | Proportion % in 1750 |
|  | 65.63 |  |
|  | 56.88 |  |
|  | 48.13 |  |
| A colorful striped banner  AI-generated content may be incorrect. | 39.38 |  |
|  | 30.63 |  |
|  | 21.88 | 40-50 |
|  | 13.13 | 40-50 |
|  | 4.38 | 1-10 |

* And compared to 2021:



|  |  |  |
| --- | --- | --- |
| Colour | Midpoint (2dp) km^2 of pasture per cell | Proportion % in 2021 |
|  | 65.63 |  |
|  | 56.88 |  |
|  | 48.13 | 10-20 |
| A colorful striped banner  AI-generated content may be incorrect. | 39.38 | 20-30 |
|  | 30.63 | 30-40 |
|  | 21.88 | 1-10 |
|  | 13.13 | 1-10 |
|  | 4.38 | 1-10 |

* Mid points are calculated such that:

|  |  |
| --- | --- |
| Percentage range (r) | Midpoint |
| 90 ≥ r < 100 | 95 |
| 80 ≥ r < 90 | 85 |
| 70 ≥ r < 80 | 75 |
| 60 ≥ r < 70 | 65 |
| 50 ≥ r < 60 | 55 |
| 40 ≥ r < 50 | 45 |
| 30 ≥ r < 40 | 35 |
| 20 ≥ r < 30 | 25 |
| 10 ≥ r < 20 | 15 |
| 1 ≥ r < 10 | 5.5 |

Midpoint estimates are added up for each county and expected to be in the range of 85-115 as a sense check for land use estimations.

There must then be conversion to ensure area of landuse calculated is in proportion to each county.

* Area of county is calculated in QGIS using shapefiles of each county and in table in supplementary data
* Each county area (in km^2) is divided by average cell size across the UK, 86km^2 calculate using arc minute conversion.:
* 9.297^2 \* cos(latitude/360 \* 2 \* 3.14159) square km.
* Where UK latitude is average of 54 degrees
* This produces number of cells within each county. Cell number is then multiplied by the percentage range midpoint and midpoint of cell value (see example below).

Tables copied from above:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Colour | Midpoint (2dp) km^2 of pasture per cell | Proportion % in 1750 | Proportion midpoint | Proportion % in 2021 | Proportion midpoint |
|  | 65.63 |  |  |  |  |
|  | 56.88 |  |  |  |  |
|  | 48.13 |  |  | 10-20 | 15 |
|  | 39.38 |  |  | 20-30 | 25 |
| A colorful striped banner  AI-generated content may be incorrect. | 30.63 |  |  | 30-40 | 35 |
|  | 21.88 | 40-50 | 45 | 1-10 | 5.5 |
|  | 13.13 | 40-50 | 45 | 1-10 | 5.5 |
|  | 4.38 | 1-10 | 5.5 | 1-10 | 5.5 |

|  |  |  |
| --- | --- | --- |
| Midpoint (2dp) km^2 of pasture per cell | 1750 km^2 \* % | 2021 km^2\*% |
| 65.63 | - |  |
| 56.88 | - |  |
| 48.13 | - | 563.2049 |
| 39.38 | - | 768.0245 |
| 30.63 | - | 836.3237 |
| 21.88 | 768.1022 | 93.87919 |
| 13.13 | 460.9315 | 56.3361 |
| 4.38 | 19.65112907 | 19.65113 |
| TOTAL | 1248.685321 | 2337.42 |

Eg for yellow highlighted cell:

Devon is 6709km^2, meaning it holds 78.0116 cells (6709/86=78.0116)

Number of cells multiplied by the proportion percentage (45%) multiplied by the midpoint km^2 of pasture in each cell is:

78.0116\*0.45\*21.88=768.1022

* The difference between 1750 and 2021is 1088.73km^2 pasture increase, which means the unit could still be functional in regard to pastural land increases as only 19.9% of the land unoccupied in 1750 is now occupied by pasture.
* BUT changes in urban area, grazing land and cropland must also be calculated using the same method
* Once calculated all 4 land types (pasture, grazing, cropland and urban area) add all 1750 together and then add all 2021. Then compare altogether.

If value of land change is over 100, e.g. it predicts more land has been converted than is available in the county, then its is capped at 100. This error arises from estimation within methods above and is expected especially within small counties.