Botanical Heatmaps and the Summarised Botanical Value Map

Technical Report

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Further information

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Executive summary

Poorly targeted tree and woodland establishment can damage wildlife and carbon-rich habitats. The need for improved access to environmental data to inform woodland establishment has become more pressing due to significant incentives from the UK Government to more than triple woodland establishment rates in England over the coming decade. Several recent high-profile examples of tree planting on botanically rich sites, highlighted the potential for perverse nature recovery outcomes when existing site interest had not been identified prior to planting.

Under the Natural Capital and Ecosystem Assessment (NCEA), Natural England have been working in partnership with the Botanical Society of Britain and Ireland (BSBI) to develop a series of botanical heatmaps derived from plant occurrence records held by the BSBI (BSBI, 2022). This project aims to create easily interpretable maps that will be available for operational use in informing tree and woodland establishment schemes and for other land use change and management interventions.

The botanical heatmaps summarise occurrence records of plant species whose presence is likely to be strongly indicative of the presence of semi-natural habitats of high wildlife value, namely (1) Rare, Scarce and Threatened species (RST) and (2) Priority Habitat Positive Indicator (PHPI) species. The latter combine published lists of species considered positive habitat indicators (BSBI axiophytes, Common Standards Monitoring positive habitat indicators, ancient woodland indicators) and were attributed to ten broad habitats.

The RST botanical heatmap displays the number of RST plant species at the hectare scale (100 x 100 m scale), allow the assessment of whether high priority plant species from a conservation perspective occur within or close to the boundary of proposed tree-planting sites. The botanical heatmaps at the monad scale (1 x 1 km grid cell) display the numbers of RST and PHPI species associated with each of the broad habitat types, identifying high quality habitats based on their botanical communities present. An additional Ancient Woodland Indicator (AWI) heatmap was also produced displaying the number of AWI species at the monad scale, to help inform the update of the Ancient Woodland Inventory. For each heatmap, the species present within each monad and the year of the last record are also provided. A map of survey coverage (number of recording days per monad) was also produced to distinguish well recorded squares from those which have been less well surveyed and require field survey and supporting data to inform site assessments.

A summarised ‘botanical value’ map was created to provide an easily interpretable output to help inform land management decision-making. This value map categorised monads as being of Low, Moderate or High botanical value according to

the presence of RST species and/or the proportion of PHPI species present in the surrounding areas (within 25km). This value map, which identifies areas likely to be rich in high quality habitat, will be shared under an Open Government Licence (OGL) and it is hoped that it will be used to guide strategic planning on a landscape scale of tree planting and other nature recovery activities.

Comparisons of the botanical heatmaps with inventories of sites of conservation importance (SSSI, Priority Habitats, Ancient Woodlands) showed that they were highly effective in identifying known sites of high conservation value, as well as highlighting sites currently excluded from protected area networks or habitat inventories. This analysis and further quality assurance by Natural England’s habitat specialists confirmed that the heatmap approach successfully identified botanically valuable sites. This provides confidence that the maps can be used to inform land use change and land management decisions and help to verify and target new sites for survey and inclusion in the national habitat inventories.

This technical document describes how these heatmap layers were developed and outlines the key limitations of these data that must be considered when using these data for land management decision-making. The most important consideration to note is that the survey coverage of the data underpinning these maps is highly variable, where in some areas of poor survey coverage the usability of the maps will be limited. In these areas, other sources of information and/or field survey should be consulted to ensure decisions are supported by the appropriate evidence.

Contents

1. Introduction

During 2020, there were a number of examples of tree-planting on sites of high botanical value thereby damaging wildlife and compromising carbon storage on some sites (Defra Press Office, 2020). This highlighted the need for better evidence to support tree planting decisions and take steps to avoid similar scenarios occurring again.

The England Trees Action Plan 2021-2024 (ETAP) sets out the UK Government's (2021) long-term vision for trees, woodlands, and forests, including increasing woodland cover in the UK to at least 12% of land cover by the middle of this century and increasing the rate of woodland establishment in England to 10,000 ha/year by 2025. This plan also includes a commitment to plant 30,000 hectares of trees per year by 2025 (UK Government, 2021). Given this unprecedented scale of tree-planting, there is an urgent need for high quality and robust environmental information to inform tree-planting activities, and especially to identify areas with existing conservation value or scope for habitat restoration. Such information is required to screen woodland and tree establishment proposals (including planting, natural colonisation and direct seeding) to ensure these do not have perverse outcomes for the nature recovery ambitions articulated under the Government's 25 Year Environment Plan, and latterly in the proposed statutory Environment Act targets.

The Botanical Society of Britain and Ireland (BSBI) maintains the largest collection of vascular plant occurrence records in the UK with a database comprising over 46 million records, spanning five centuries. These have been collected by amateur and professional botanists in a voluntary capacity, mainly since the 1950s as part of national atlas recording campaigns (Perring & Walters, 1962; Preston et al., 2002; Stroh et al., in prep) and county-wide flora surveys.

The BSBI have been working in partnership with Natural England and the Woodland Trust since early 2020 to utilise these data to inform tree planting. This led to the development of a series of coincidence maps ('heatmaps') at the monad (1 x 1 km grid cell) and hectare (100 x 100 m grid cell) scales that summarised the numbers of Nationally Rare, Scarce and Threatened (RST) and Priority Habitat Positive Indicators (PHPIs) recorded as present. These species were chosen for heatmapping as their locations are likely to indicate areas of good quality semi-natural habitat and therefore areas to be avoided by potentially damaging activities such as tree-planting.

Under the NCEA Tree Strategy project, this heatmapping approach has been developed further as easily interpretable spatial data layers to inform operational advice and decision-making, in particular, for assessing the suitability of sites for tree and woodland establishment. These maps could also be used to support decision-making in other key policy areas; for example, by helping to verify high nature value sites, targeting surveys to support updates to national habitat inventories, supporting environmental impact assessments, informing Local Nature Recovery Partnership Strategies and targeting areas for restoration under proposed Environmental Land Management Schemes.

2. Data sources

The data underpinning the botanical heatmaps were vascular plant species occurrence records held centrally in the BSBI's distribution database (BSBI, 2022). We included records collected between 1970 and 2021 captured at 1 x 1 km resolution for PHPI species, and at 100 x 100 m resolution for RST species. These resolutions were chosen as they represent the greatest utility in informing tree planting at the site and landscape level. RST species are typically recorded by BSBI recorders at high resolutions because they are of highest priority for conservation. Equally, they are the species most likely to pin-point areas of high-quality semi-natural habitat on the ground and so have the greatest value in informing land management activities, such as tree-planting, at a detailed site level. In comparison, many of the PHPI species are more widely distributed and therefore more likely to be routinely recorded at the 1 x 1 km (or 2 x 2 km) resolution. As a result, the 1 x 1 km resolution was chosen for summarising their distributions, although it should be noted that the BSBI database includes many high-resolution records for these PHPI species. BSBI plant records were therefore supplied as species counts at the two different spatial resolutions:

1. **The number of Nationally Rare, Scarce and Threatened (RST) species per 100 x 100 m and 1 x 1 km resolution**. The coincidence of species classified as Nationally Rare or Scarce (Wiggington, 1999; Stewart et al 1994), or threatened according to the Vascular Plant Red Data List for Great Britain (Cheffings & Farrell, 2005). The threatened species include all extant species listed as Critically Endangered (CE), Endangered (EN), Vulnerable (VU) or Near Threatened (NT). Note that these lists are not mutually exclusive as some rare or scarce species are also considered to be threatened. For each grid cell, a list of the species recorded as present and the year the most recent record was captured was also supplied.

2. **The number of Priority Habitat Positive Indicators (PHPI) species per 1 x 1 km resolution**: the coincidence of species considered to be positive indicators of high quality semi-natural habitats. These were compiled from published lists of positive indicators that have been rigorously assessed by botanical experts and habitat specialists. These included:
    - BSBI axiophytes, compiled from lists produced for around 25 vice-counties by expert field botanists to identify sites important for

conservation and indicative of good quality semi-natural habitats (Walker 2018),

- Positive habitat indicators listed for UK priority habitat types taken from the Common Standards Monitoring guidance for Sites of Special Scientific Interest (SSSI) (JNCC, 2004).
- Ancient woodland indicators (as summarised by Glaves et al., 2009) whose presence indicate the long continuity of woodland cover.

To provide an indication of habitat association, each species was then attributed to the broad habitats given in Plantatt (Hill et al., 2004). For ease of interpretation, we combined several of the Plantatt habitats into ten broad habitats described in Table 1.

Table 1. The broad habitat categories and the number of Priority Habitat Positive Indicator (PHPI) species assigned to each broad habitat, derived from the Plantatt habitat categories (Hill et al., 2004).

Broad habitat type	PHPI species	Plantatt broad habitat categories
Woodland	223	Broadleaved, mixed, yew & coniferous woodland
Arable	80	Arable and horticulture (includes orchards, excludes domestic gardens)
Boundary & linear	189	Boundary and linear features
Grassland	352	Neutral, calcareous & acid grassland; bracken; improved grassland
Fen, marsh, swamp	217	Fen, marsh and swamp
Heath & bog	95	Dwarf shrub heath; bog
Montane	98	Montane habitats (acid grassland and heath with montane species)
Inland rock	248	Inland Rock
Water	185	Standing water, canals, rivers and streams
Coast	162	Supralittoral rock and sediment, littoral sediment (saltmarsh), inshore sublittoral sediment

Natural England habitat specialists assessed the suitability of the indicator species lists for informing this analysis, and as a consequence a small number of revisions were made. The indicator species list used are available in the supplementary data ‘NERR110_postitive_indicators_March2022.csv’.

As with all taxonomic groups, the level of biological recording undertaken by volunteers (recording intensity) varies both spatially and temporally due to a variety of factors, most notably the scale at which botanical records are routinely collected, as well as the accessibility and the number of active recorders within an area. Wherever possible, it is important to take these variations into account as recorder effort can strongly influence the number of RST and PHPI species observed in a given area (all other things being equal) and therefore influence our confidence in the ability of the heatmaps to reliably flag areas of semi-natural habitat interest. To address this, we sought to objectively capture this recording intensity (here termed survey coverage) by incorporating an additional layer of data supplied by the BSBI:

3. **Survey coverage per 1 x 1 km resolution**: this was quantified as the number of 'recording days' undertaken in each grid cell. A 'recording day' is here defined as a single recording event where 40 or more taxa were recorded during a single visit. 40 species is widely accepted as a good lower benchmark for recording plants at the monad scale during a single visit (Walker, K.J. 2022). The number of recording days therefore provides a reliable proxy of recording intensity (i.e., how well surveyed it has been by volunteers).

As well as data from the BSBI, supporting data were obtained from other sources for the spatial analysis. The Ordnance Survey (2021) British National Grids were used as a spatial framework for the grid cell divisions of 100 x 100 m (hectares), 1 x 1 km (monads) and 100 x 100 km (myriads). For regional and country boundaries, spatial data were obtained from the Office for National Statistics (2020) Open Geography Portal. These data were all available under an Open Government Licence. Additional datasets were used to validate the heatmaps and included the Sites of Special Scientific Interest (SSSIs), Priority Habitats Inventory (PHI) and the Ancient Woodlands Inventory layers, all of which are maintained by Natural England (2022, 2021a, 2021b).

3. Methodology

All processing of the data layers and spatial analyses were carried out in R version 4.1.2 and R Studio v.1.3.1056.

3.1 Survey coverage and benchmarking

As set out above, survey coverage was a key consideration when developing the heatmaps due to variation in recording effort that is usually inherent in biological recording datasets collected opportunistically by volunteers. As a consequence, the diversity of PHPI species is expected to show a degree of variation across England, over and above the normal variation caused by differences in geology, climate and land use. This was particularly evident in counties where recent botanical surveys have been primarily undertaken at the tetrad scale (2 x 2 km grid cells) (e.g., Devon and Sussex), when compared to neighbouring counties where surveys have been undertaken at the monad scale (1 x 1 km grid cells) (e.g., Cornwall, Somerset, Dorset, Hampshire and Kent).

To account for these variations in survey coverage, and ensure complete coverage of the data across England, we first looked to establish whether monads had been 'well surveyed' or not. This was a critical step as it allowed us to establish, with some confidence, whether an apparent absence of botanical interest within a monad was real or simply because the square had not been adequately surveyed. Specifically, we attempted to differentiate monads where the absence of PHPI species was real (i.e., squares that had been well-surveyed, but few PHPI species had been recorded), from those where apparent absences were more likely to be due to a lack of recording. Being able to differentiate between these two scenarios is crucial for decision-making, as it determines the degree of confidence, we have in the data presented.

The degree of survey effort was calculated by first determining the number of ‘recording days’ for each monad. To provide a clearer definition of ‘well surveyed’, this was then plotted against the total number of plant species recorded for all monads in England using data supplied by the BSBI.

Using linear regression, these data predicted that after approximately 3 recorder days, over 200 taxa were likely to have been recorded per monad. As a general rule, a monad is considered to be ‘well recorded’ by expert botanists if 200 or more taxa have been recorded and, as Figure 1 shows, this was achieved in most regions across England after around 3 recording days. Consequently, we used 3 recording days as a benchmark for when a monad had been well recorded.

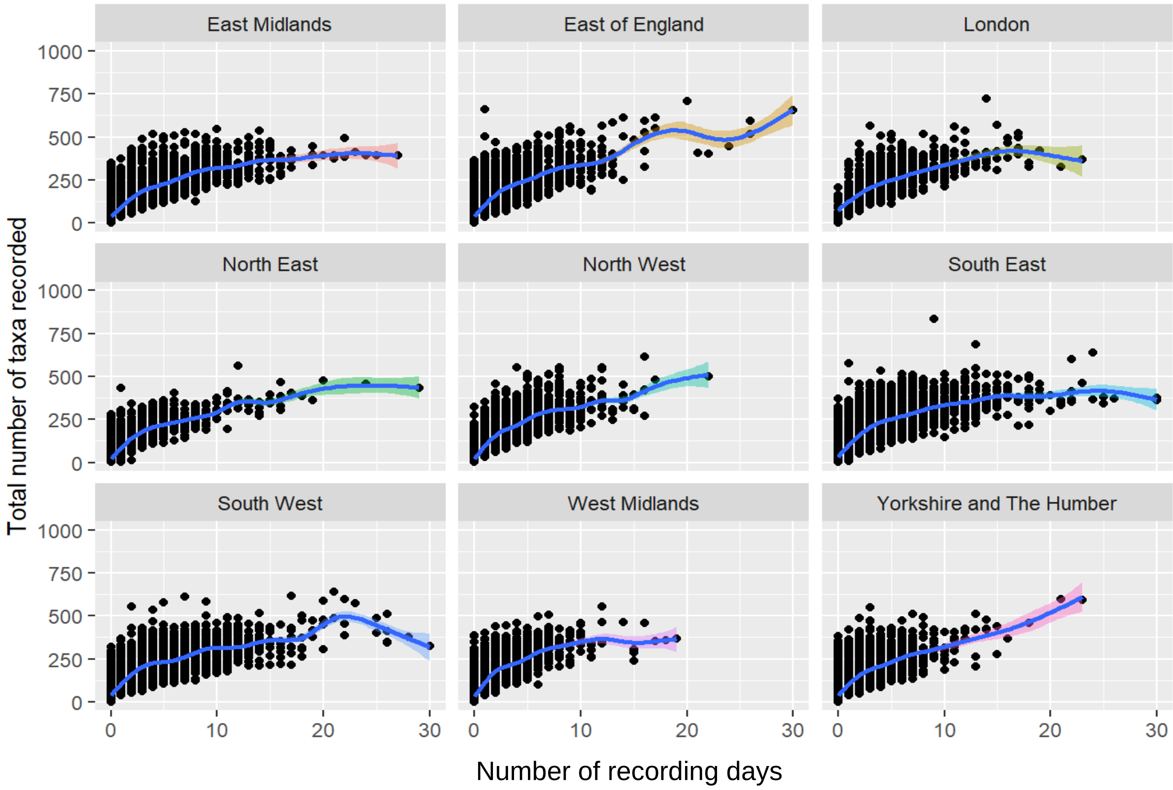


Figure 1. The relationship between the number of recording days against the total number plant taxa recorded in monads in England, 1970-2021, broken down by region.

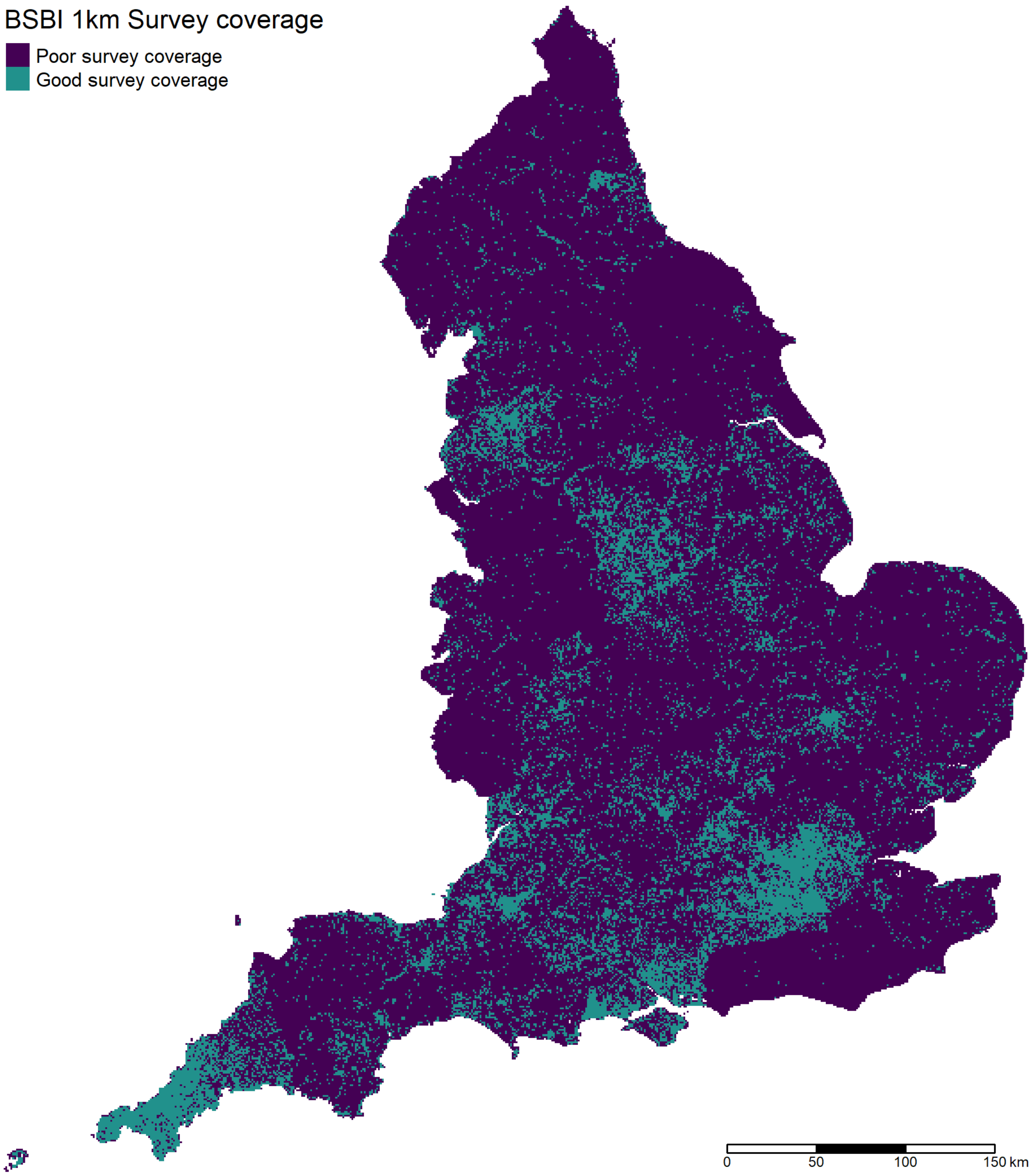


Figure 2. The survey coverage achieved by BSBI volunteers between 1970 and 2021 at 1 x 1 km resolution, based on the number of recording days. 'Poor survey coverage' are monads with less than 3 recording days, and 'good survey coverage' are monads where 3 or more recording days have been observed. © Copyright Natural England & Botanical Society of Britain and Ireland. Map attribution: Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

As is clearly shown in Figure 2, the number of recording days was found to vary significantly between and within regions at the monad scale. To a large extent this is to be expected due to differences in soil type, geology, climate and land use between different areas and regions, but there were also marked differences between similar areas due to recording behaviour. Possibly the most notable example is the difference in recording coverage between the neighbouring counties of Cornwall and Devon. Since 1970, Cornwall has been comprehensively surveyed twice at the monad scale during the production of two floras of the county (French, et al., 1999; French, 2020), whereas Devon has only been recorded once and only at the tetrad scale (Smith et al., 2016). Consequently, the average number of PHPI species per monad in Cornwall is 3.62 compared to 1.05 in Devon. Similar differences are clearly visible between Sussex and its adjacent counties due to it having only been surveyed at the tetrad scale in recent decades (Abraham et al., 2018), whereas Hampshire, Kent and Surrey have all been routinely recorded at the monad scale.

In this analysis, we have chosen to only use records for PHPI species captured at the monad level. This approach therefore excludes the large number of records in BSBI database captured at the tetrad scale in counties such as Devon and Sussex. Further development work will therefore be required to investigate how these tetrad records can be integrated in future assessments to help inform tree-planting.

It should be noted, the lack of monad data will reduce the utility of the heatmaps in some counties (Devon, Sussex, Herefordshire, South Lancashire, North-east Yorkshire) and so in these areas the maps should be used ‘with caution’, especially when a given monad is categorised as having ‘poor survey coverage’. In these areas, the numbers of PHPI species are likely to be underestimated and therefore unreliable as an indication of the quality of the semi-natural habitats present.

3.2 Botanical heatmaps

A geopackage was created at the 1 x 1 km resolution summarising species counts per monad for RST and PHPI species. A second geopackage was also created for Ancient Woodland Indicators (Glaves et al., 2009) for use within the NCEA to help support updates to the Ancient Woodland Inventory. These geopackages were created by first subsetting the OS British National 1-km grid to the boundary for England. Each monad was then attributed with the number of recorder days and intersected with the regional boundaries, to extract the administrative region each monad was nested within. The RST, PHPI and AWI counts were then associated with the monads to create the geopackage layers.

Where there were no indicator species listed for a given monad, and the monad had good survey coverage (i.e., it had 3 or more recorder days) then it was categorised, with some confidence, as having no indicators present. If there were no indicators listed for a given monad, but survey coverage was poor (i.e., it had less than 3 recorder days), then the indicator total was given as ‘no data value’ (-9999) to flag squares where further survey effort or other information would be required prior to any decision being made on whether trees could be planted on a given site.

This was carried out for each of the AWI species, RSI plant species and PHPI species. The geopackages contain a vector layer of the indicator counts per monad, and associated tables with attribute data for the recorded species and latest year they were recorded. Examples of the heatmaps created for AWIs and PHPI species individual broad habitat heatmaps are shown in Figure 3 and 4.

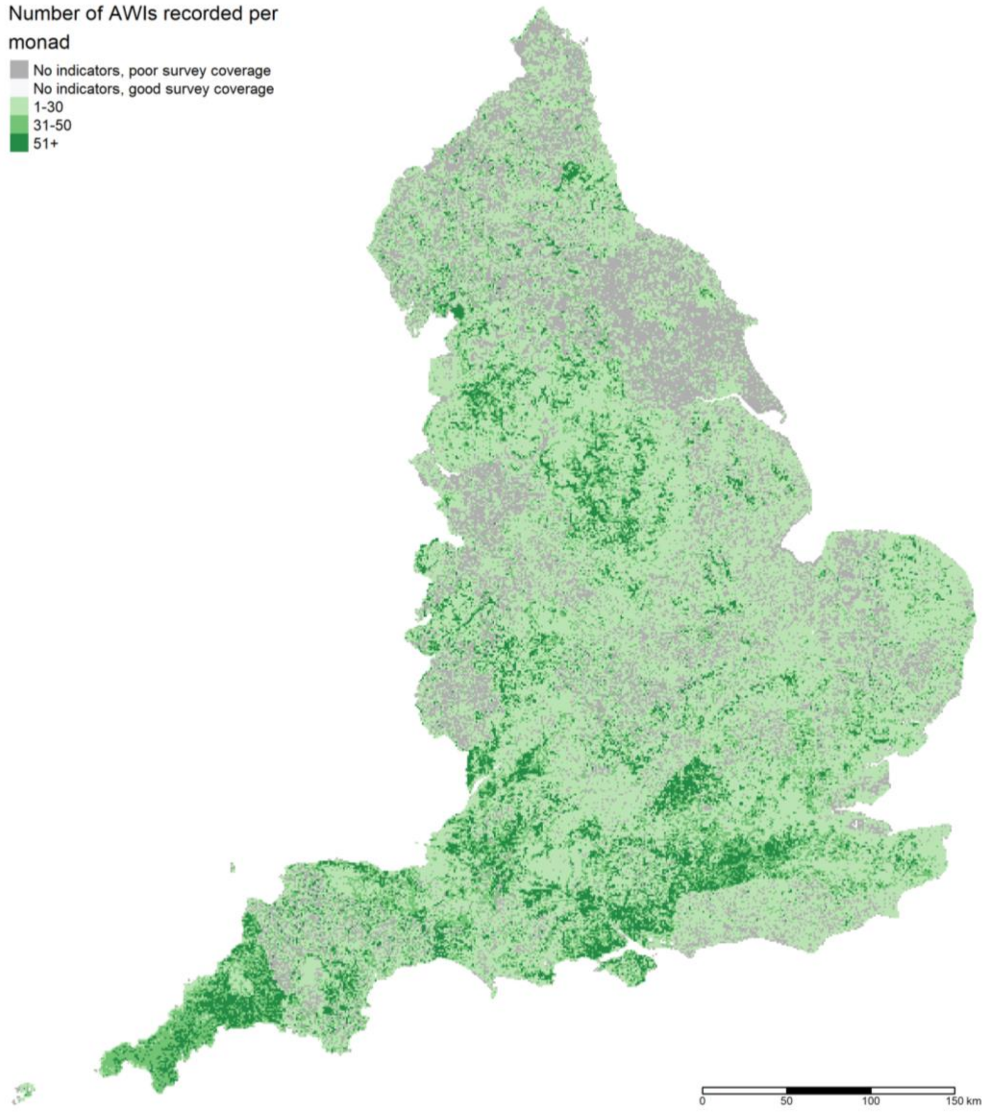


Figure 3. The botanical heatmap showing the number of ancient woodland indicator species (after Glaves et al., 2008) recorded within 1 x 1 km (monad) grid cells in England between 1970-2021. © Copyright Natural England & Botanical Society of Britain and Ireland. Map attribution: Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

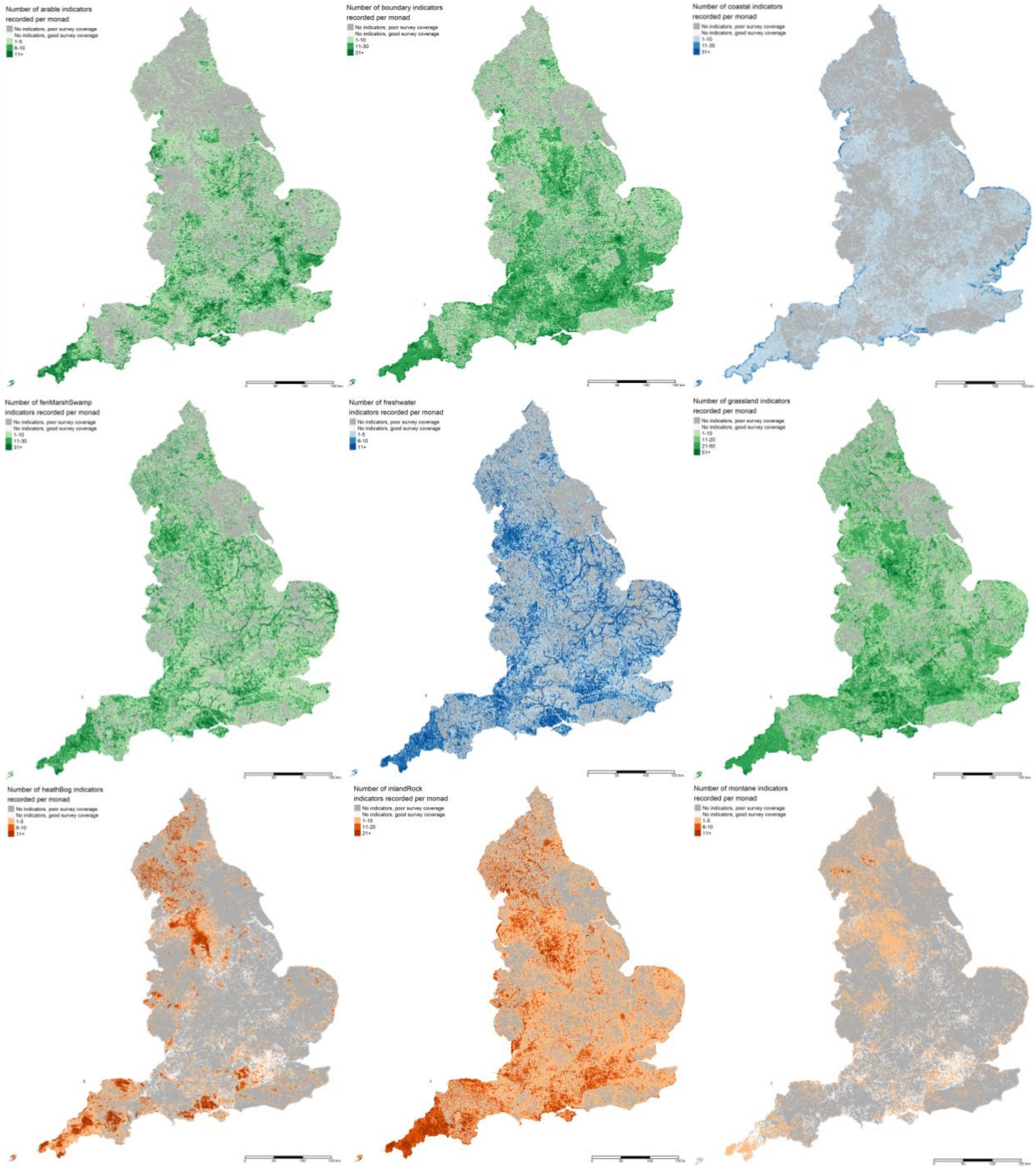
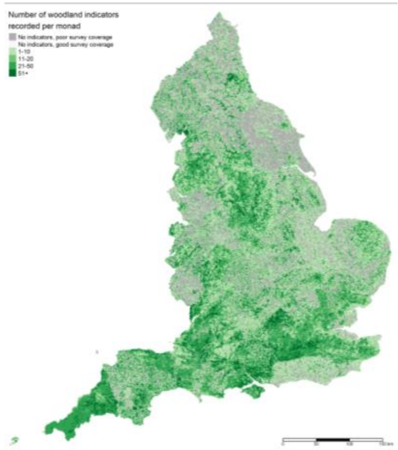


Figure 4. The botanical heatmaps showing the number of Priority Habitat Positive Indicators (PHPI) species recorded in 1 x 1 km (monad) grid cells in England between 1970-2021 for ten broad habitats: from left to right, (top) Arable; Boundary; Coastal; Fen, Marsh & Swamp; Freshwater; (bottom) Grassland; Heath & Bog; Inland Rock; Montane; and Woodland. © Copyright Natural England & Botanical Society of Britain and Ireland. Map attribution: Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.



A third geopackage was created at the 100 x 100 m resolution using the RST plant species data supplied by BSBI. This layer is intended to be used as the highest precision layer to pinpoint whether any high priority plant species from a conservation perspective occur within or close to the boundary of proposed tree-planting sites. It is therefore particularly important for informing site-based screening of tree and woodland establishment and identifying areas of highest botanical value which require protection.

The spatial layers and table attributes for the botanical heatmaps and the summarised botanical value data layers are described in Appendix 1: Botanical heatmap and botanical value map data attributes.

3.3 Summarised Botanical value map

This map summarises the RST and PHPI heatmap data assigning each monad (1 x 1 km grid cell) as being high, moderate, or low value for plant species. The value for plant species is assigned according to a combination for two data layers:

1. the presence of RST plant species
2. the presence of PHPI species indicating areas of good quality semi-natural habitat

This was created to provide a simple and easily interpretable map layer intended to be used by a wide range of practitioners, with little or no botanical expertise, involved in tree-planting or wider nature recovery decision-making.

On its own, this map cannot be used to carry out detailed assessments of individual site suitability for tree planting, for which the RST plant species heatmap at 100 x 100 m resolution and the PHPI heatmaps at 1 x 1 km resolution need to be consulted. However, the value map can provide useful insights at a strategic landscape scale, to highlight monads of high botanical value that can be targeted during spatial planning and prioritisation, and other land management decision-making.

Layer 1: Presence of RST plant species

This is to show any area where a species of national conservation concern or importance have been previously recorded, indicating the likely presence of high value sites for biodiversity within a monad. This was derived from the RST plant species heatmap, where the higher resolution records at 100 m resolution have been aggregated to the monad scale. Monads were then either categorised as having ‘no indicators’ if no RST plant species were recorded present, with an indication of survey effort carried out within that monad, or as ‘High’ if one or more RST plant species had been recorded present. In total, 22,949 monads in England (17%) were found to be of ‘High’ value with one or more RST plant species recorded present, shown in Figure 5.

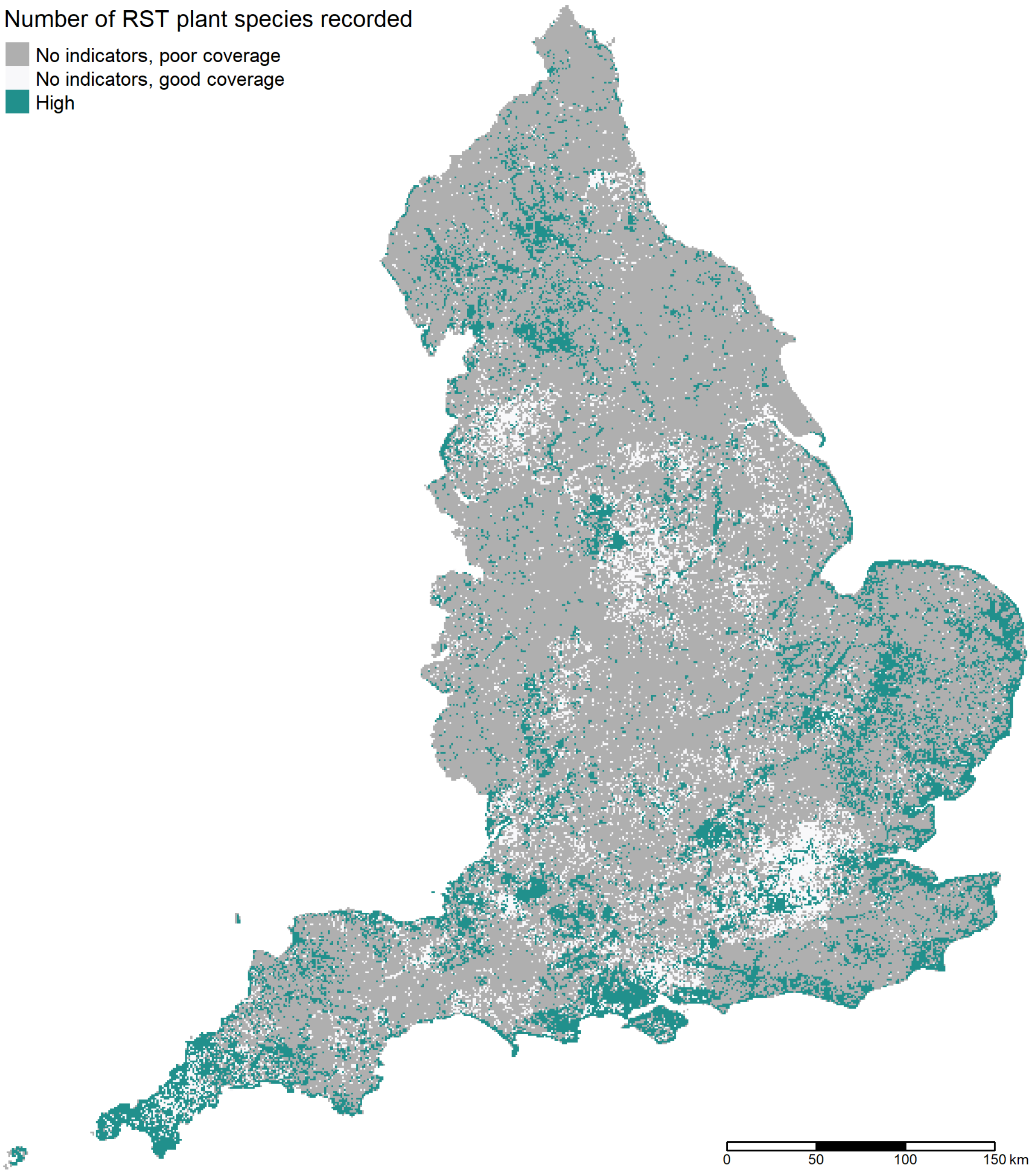


Figure 5: The distribution of Rare, Scarce and Threatened (RST) plant species at the monad scale (1 x 1 km grid cells) in England. 'High' represents monads with one or more RST species present; 'no indicators, good coverage' represents monads with good survey coverage, but no RST species recorded; ''no indicators, poor coverage' indicates monads with poor survey coverage (<3 recording days) and no RST plant species recorded. © Copyright Natural England & Botanical Society of Britain and Ireland. Map attribution: Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

Layer 2: Presence of PHPI species

This data layer was developed to identify monads likely to support good quality semi-natural habitats that should be protected, based on the coincidence of PHPI species. To provide a measure of habitat quality, benchmarks were applied to each broad habitat PHPI heatmap based on the number of species present within each monad. This was transformed through ‘local benchmarking’ to take account of local variations in the numbers of PHPIs, categorising monads into low, moderate, and high values based on the proportion of PHPIs in each monad compared with the total number of PHPIs in the monad’s surrounding area.

Local benchmarking

There are several biases which need to be considered when using occurrence data to ascertain habitat quality. Aside from issues surrounding survey coverage and recording bias (described in Section 3.1), one of the most important is the ‘natural’ spatial variation in the occurrences of plant species, most notably the decline in plant species diversity which occurs towards the poles, often termed the Latitudinal Diversity Gradient (Brown, 2014). It is important to take this factor into account, as habitats in southern England will be, on average, more diverse than their equivalents in northern England, simply because more species occur in the south. Each broad habitat PHPI heatmap was assessed individually through ‘local benchmarking’ to address this. This was where the number of PHPI species in each monad was converted into a proportion, based on the total number of PHPI species that were present within the surrounding area (i.e., the monad’s local neighbourhood). So that these maps were easy to use and interpret by practitioners with little or no botanical expertise, these proportions were then converted into ‘Low’, ‘Moderate’ and ‘High’ value categories.

We tested three local neighbourhoods as part of this benchmarking: (1) the administrative region, (2) the 100 x 100 km OS grid square (myriad) and (3) a ‘moving neighbourhood’ defined as all the monads within a given radius. These analyses are described in detail in Appendix 2: Local benchmarking analysis. Along with the local neighbourhoods, we also trialled the distance radius to apply with the ‘moving neighbourhood’ approach (3), and the threshold ranges to use to define the low, moderate and high categories.

Natural England’s national habitat specialists and BSBI staff were consulted to compare the results of these three analyses. Overall, the differences between them were very small, but the best approach was felt to be the 25 km moving neighbourhood of monads, as this was considered to provide a suitable resolution for capturing differences in botanical and habitat variation across England. Several thresholds and ranges were trialled for benchmarking the value categories. Threshold proportions of 10% and 20% of PHPIs were selected on the grounds that these provided a good distribution between the value categories and most importantly effectively flagged the most important monads as ‘High’ value. Accordingly, where the monad contained less than 10% of the total number of indicators present in the moving neighbourhood it was classified as being of ‘Low’ value. Where it contained between 10-20% it was classified as being of ‘Moderate’ value, and over 20% as being of ‘High’ value.

The summarised botanical value

To produce the summarised botanical value map, the two data layers were combined, and the highest value category was assigned as the overall score for each monad. It is recognised that this applies a precautionary approach as it can potentially categorise a monad as 'High value' even where only one RST plant species has been recorded as present or where a monad is classified as 'High value' based on only one of the ten broad habitat PHPI heatmaps. Monads were categorised as 'no indicators, poor survey coverage' where survey coverage was poor (i.e., less than 3 recording days) and no RST or PHPI species were recorded.

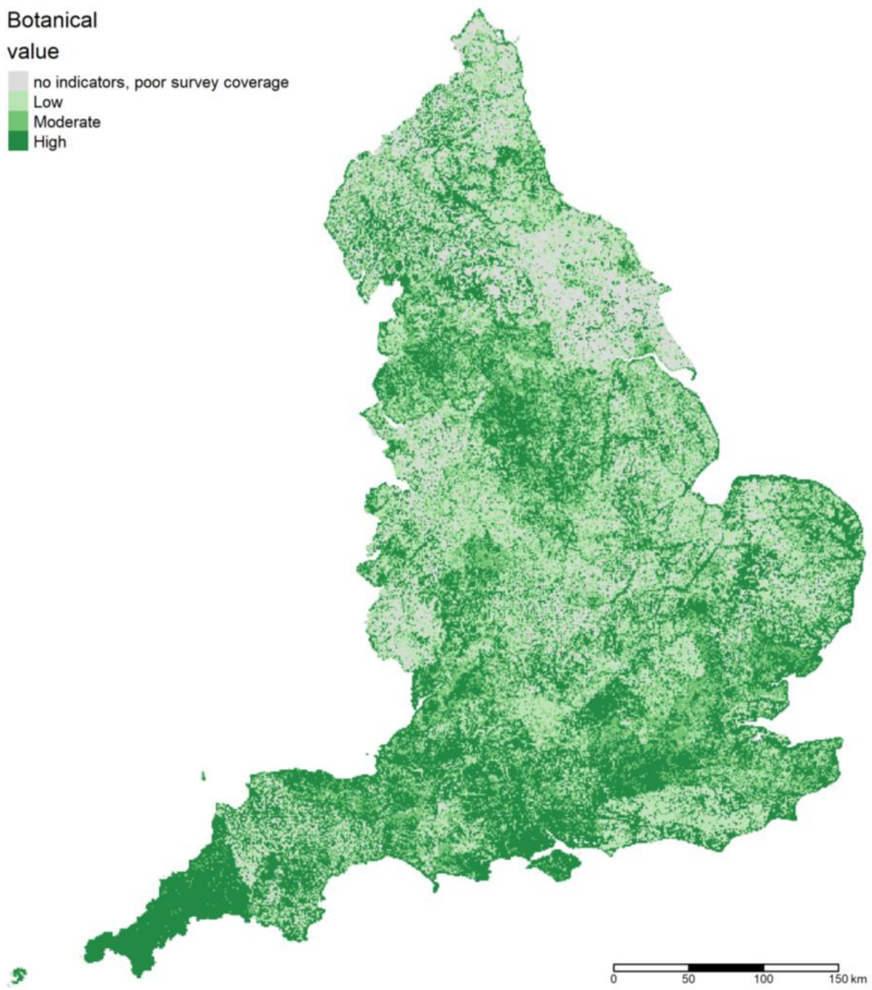


Figure 6: The overall botanical value map based on the combined information on the numbers of Rare, Scarce and Threatened (RST) and priority habitat positive indicators (PHPI) plant species recorded between in monads between 1970-2021. See text for explanation of how the values were derived. © Copyright Natural England & Botanical Society of Britain and Ireland. Map attribution: Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

These data layers have been produced with a repeatable automated workflow and so can be updated when new records are made available by BSBI as part of the annual updates to the maps.

The summarised botanical value mapped 35% of English monads as being of High botanical value, equivalent to 47221 monads. Clipped to the English coastline, High value areas cover approximately 45,470 km^2. 23% of monads were classified as Moderate value (approx. 30,445 km^2) and 29% of monads were classified as Low value (approx. 38,179 km^2) for vascular plants. 13% of monads were found to be of poor survey coverage requiring further survey and additional information to inform land management decisions.

4. Data validation

To evaluate the extent to which the botanical heatmaps and the summarised botanical value map could flag areas of known habitat interest, the maps were compared to inventories of sites of high biodiversity interest. These were:

- Sites of Special Scientific Interest (SSSI)
- Priority Habitat Inventory (PHI)
- Ancient Woodland Inventory (AWI)

4.1 Comparison with SSSI sites

All monads either completely containing or overlapping the boundaries of Sites of Special Scientific Interest (SSSI) in England were identified and assessed to see how many PHPIs they contained. Overall, 90% of monads associated with SSSIs had at least one RST species recorded and 9% had five or more RST plant species recorded. Likewise, 92% of the monads associated with SSSIs had at least one PHPI species, 71% had more than 25 PHPIs and 56% had over 50 PHPIs recorded. In terms of survey coverage, 27% of overlapping monads were well surveyed (3 or more recording days), whereas only 10% of monads had no recording days. Comparisons with the summarised botanical value map showed 63% of monads associated with SSSIs were categorised as High value, 14% as Moderate and 15% as Low.

These figures demonstrate good correlation between the RST and PHPI species and SSSI locations, which is to be expected as many of the RST plant species, and to some extent the PHPI species, are likely to be designated vascular plant features on many SSSIs.

4.2 Comparison with Priority Habitat Inventory sites

Reassuringly, PHPI species were recorded in all of the monads containing or overlapping with the boundaries of Priority Habitat Inventory (PHI) sites in England. An example of the spatial correlation between these PHI sites and PHPI species in Gloucestershire is displayed in Figure 8.

The inventory sites were then aggregated according to UK BAP broad habitats (JNCC, 2011) based on the priority habitat features known to be present on the inventory site. These were then compared against the individual PHPI heatmaps for the relevant broad habitat classes. This analysis is summarised in Table 2.

Table 2: The percentage of English monads containing Priority Habitat Inventory (PHI) sites in relation to the number of priority habitat positive indicator (PHPI) species recorded by broad habitat (0, >10, >30).

Broad habitat	% monads with no PHPI species	% monads with over 10 PHPI species	% monads with over 30 PHPI species
Woodland	0.003	57	25
Grassland	0	67	33
Fen, Marsh & Swamp	0	65	8
Heath and Bog	0.35	30	0.7
Coastal	0.19	68	10
Inland Rock	0	72	21

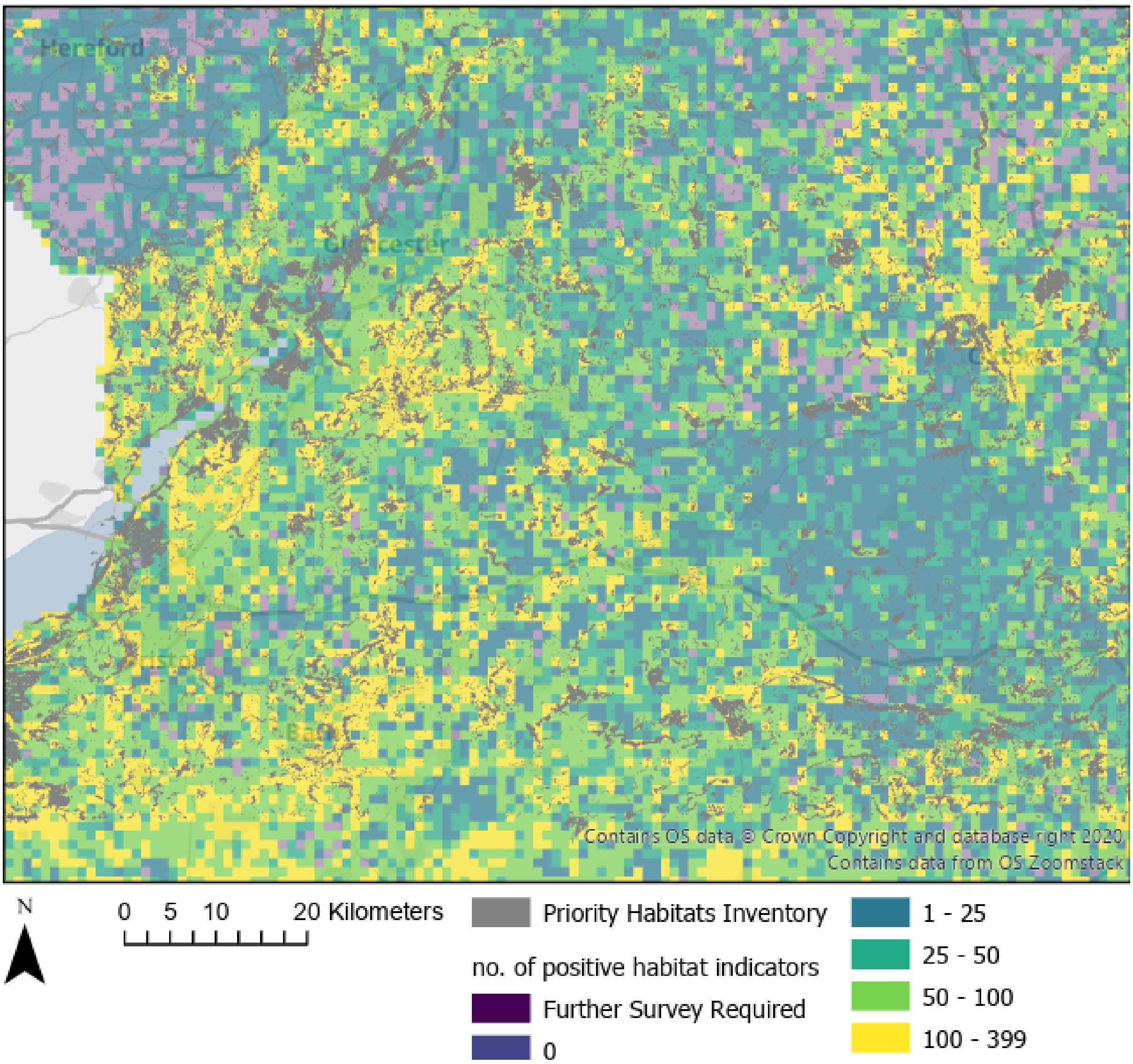


Figure 7: A map of the Priority Habitat Inventory (PHI) sites in Gloucestershire with the number of priority habitat positive indicator (PHPI) species per monad overlaid. © Copyright Natural England & Botanical Society of Britain and Ireland. Map attribution: Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

The heatmaps demonstrated that PHPI species associated with the relevant broad habitats were present on the majority of Inventory sites. With the exception of Heath and Bog, the majority of overlapping monads were recorded to have ten or more PHPI species present. Heath and Bog habitats have comparatively fewer positive indicators associated with them, and a greater range of contributing priority habitats which may explain this finding.

4.3 Comparison with Ancient Woodland Inventory sites

An analysis of the numbers of Ancient Woodland Indicator (AWI) species (Glaves et al., 2008) and sites included in the Ancient Woodland Inventory revealed that all monads containing or overlapping inventory sites had at least one AWI species. Important areas for ancient woodland were clearly distinguished on the botanical heatmaps. For example, in Figure 9, the heatmaps clearly highlight high concentrations of ancient woodlands in the Forest of Dean, the Cotswolds, near to Oxford and along the Chiltern ridge. Natural England's woodland habitat specialists noted the ability of the heatmaps to highlight even very small, isolated woodlands of great botanical importance in the Thames valley. Crucially, the heatmap output identified a considerable number of sites with 10 or more AWI species, which are currently not included in the inventory. A comparison of these sites with Natural England's (2021c) Wood Pasture and Parkland Inventory (WPPI) revealed a high coincidence with this habitat inventory, not unsurprisingly given the high level of cross-over in habitat indicator species associated with wood pasture and woodland

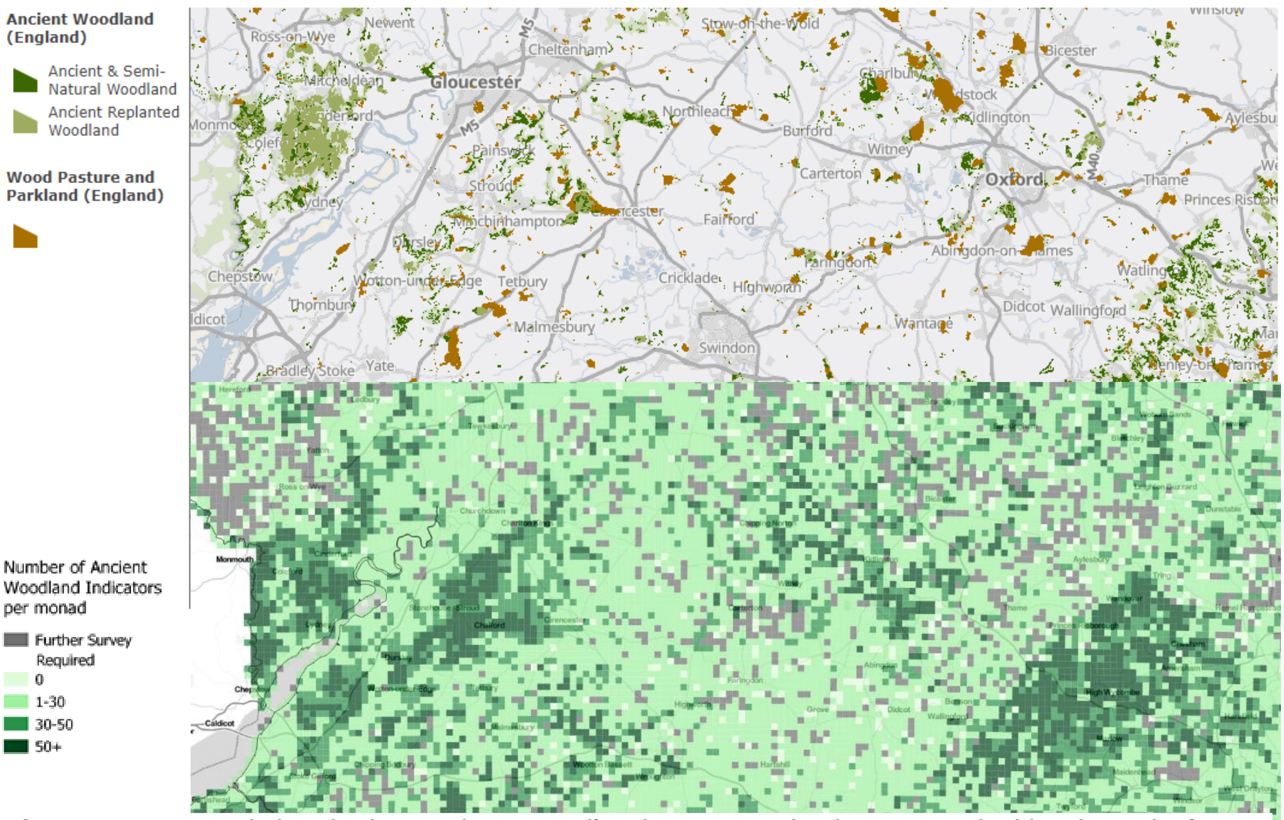


Figure 9: A map of sites in the Ancient Woodland Inventory (top) compared with a botanical heatmap of the number of ancient woodland indicator species recorded in monads 1970-2021 (bottom). © Copyright Natural England & Botanical Society of Britain and Ireland. Map attribution: Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

systems. This demonstrates the utility of the botanical heatmaps in helping to identify areas of long-established wood pasture and parkland, as well as additional ancient woodlands, for inclusion in the Ancient Woodland Inventory as part of ongoing reviews and updates. The botanical heatmap output also has significant potential value for targeting the creation of new native woodland in areas where the ancient woodland ground flora persists, allowing woodland ecosystems to be more readily restored.

5. Key findings

The botanical heatmaps provide a very efficient and effective means of identifying areas of high diversity for a wide range of plant species indicative of areas of high habitat quality. The Rare, Scarce and Threatened (RST) plant species heatmap allow for the identification, with high confidence and precision, of the important botanical sites from a vascular plant perspective, thereby informing detailed site assessments for tree-planting and other nature recovery activities. Likewise, PHPI species heatmaps help to identify monads with high quality habitat based on botanical species records. Whilst survey coverage does vary greatly across England, the analyses can help to target areas where data gaps exist in our current understanding of botanical value and where further data collection is required. This work has also demonstrated the need for volunteers to capture records at least at the monad resolution and, where this is not possible, the areas where future iterations of the heatmaps may look to incorporate data collected at 2 x 2 km (tetrad scale).

Validation against existing inventories of priority sites and habitats has revealed a very strong correlation with the botanical heatmap outputs; PHPI species are present in all monads overlapping with PHI sites and 92% of SSSI sites, with 71% of SSSIs supporting more than 25 PHPI species. Furthermore, 77% of monads overlapping with SSSI sites were classed as being of High or Moderate value in the summarised botanical value map. There was also very good correlation between the botanical heatmaps for individual broad habitats within inventory sites, including ancient woodlands.

These analyses provide high confidence in the utility of the botanical heatmaps in flagging important botanical sites for conservation and for informing land management decision-making, including screening sites for tree planting. In addition, they have great potential for helping to identify and verify sites for inclusion in national habitat inventories.

6. Limitations and considerations for use

Several caveats need to be considered when employing the botanical heatmaps presented here for the uses listed in Section 5. Whilst they draw on the BSBI's substantive data holdings, it is important to understand the following:

1. The records that underpin the maps are not comprehensive, as botanical volunteers have not recorded all areas at the same scale or with equal intensity. The reasons for this are varied but mainly relate to the design of local recording schemes, how active local volunteers and groups are, access limitations, remoteness, terrain, etc. We have addressed this to some extent by quantifying recording effort, but it should be stressed that no one method is perfect and that the maps presented here remain highly biased and incomplete in some areas across England.

2. The PHPI and AWI species heatmaps are mapped at 1 x 1 km resolution and consequently they can only indicate areas where botanically valuable habitats **are likely to be** present, not the exact locations. In comparison, the high-resolution RST species layer can pinpoint areas of high botanical value very precisely and therefore should always be used in the first instance when screening sites for tree-planting.

3. For the purposes of this project, we have only used records for PHPI species captured at the monad scale (1 x 1 km). Consequently, there a number of counties where the heatmap coverage is poor as records for PHPI species in those counties have been routinely captured at tetrad scale (2 x 2 km). Therefore, other sources of information and/or field survey are needed when assessing sites for tree-planting in these counties (Devon, Sussex, Herefordshire, South Lancashire, North-east Yorkshire).

4. The botanical heatmaps and summarised botanical value map aim to provide evidence to inform where high value sites for vascular plants are located, to be considered when making decisions for tree planting activities. Other sources of environmental information that can help inform decision-making include aerial photos, soil maps and information from local experts and, wherever possible, these should be used alongside the heatmaps to help identify locations of high nature value habitat. For example, the BSBI themselves hold many high-resolution records for the PHPI species that could also be used. If there is any doubt about the environmental value of a site, a field visit at the appropriate time of year (May to September) by a competent botanist should be undertaken before any change to land use/ management is made.

5. For the RST species list, we used assessments carried out for Great Britain with the data extracted by BSBI originally having a whole UK coverage, although for this analysis England-level assessments would have been preferable. However, a quick assessment of the England RST species list showed that the majority were already

included, albeit with slightly differing statuses. Globally or highly restricted endemic species were not reviewed, although many are likely to fall within the RST species list used.

6. The botanical value map provides a very precautionary approach to assessing botanical value, as monads categorised as high value only require a single RST species to be present or a single broad habitat to achieve high value (i.e., more than 20% of the PHPI species present in the surrounding area). We therefore recommend that its use is limited to providing a high-level spatial overview of indicative botanical value to inform national-scale planning. The higher resolution RST species layer and individual broad habitat PHPI heatmaps should be used to provide greater insights into the botanical value of each monad and species present within these, as well as habitat interest likely to be supported there.

7. Recommendations

1. The heatmaps should be refreshed annually with the most up-to-date species records from the BSBI, to ensure these maps continue to reflect the best available evidence on the locations of RST and PHPI species.

2. Where possible, habitat survey and species recording should be carried out at least at the monad scale and targeted to areas of poor survey coverage, to ensure the maps provide more comprehensive coverage across England.

3. Identify and commission spatially targeted habitat surveys where the individual broad habitat heatmaps and the AWI heatmap identify obvious gaps in Natural England's existing Priority Habitat and Ancient Woodland Inventories.

4. Explore the applicability of the proportional thresholds used for benchmarking to provide an indication of relative botanical value. Determine whether varying these thresholds or the spatial radius applied to the 'moving neighbourhood' would help improve the analysis.

5. Further development to incorporate other BSBI data recorded at the tetrad scale (2 x 2 km) or PHPI species data at higher resolutions where this exists. This would help to fill in gaps in survey coverage and improve the representation of indicator species shown on the maps.

6. Explore further use cases of the data and botanical value attributed alongside heatmaps of other valuable biological groups, for instance fungi groups or important sites for breeding birds. This will support the creation of a biological toolkit which will helpfully inform tree and woodland establishment activities and wider land management/land use change decisions.

7. Compare the botanical heatmaps with maps of habitat distribution and extent, such as the Living England habitat probability map or England Peat Map, to explore how

the heatmaps might feed into and help verify habitat classifications, using species level data.

8. Data access and format

8.1 Download and data Format

The summarised botanical value map will be made available to view on the Defra's MAGIC platform (MAGIC, 2022), Natural England Open data portal (Natural England, 2021d) and Defra Data Services Platform (Defra 2022) with download access available via data.gov.

The botanical heatmaps provide more detailed information on the number of species indictors present within monads or at a site scale (100 x 100 m). Due to the sensitive nature of some of these data, these layers will only be made available for conservation purposes under more restrictive licencing. Requests to access these data should be made to Natural England by emailing botanicalheatmaps@naturalengland.org.uk.

The PHPI species list compiled for this project is available in the supplementary data 'NERR110_postitive_indicators_March2022.csv', made available alongside this report.

8.2 Geographical extent

The botanical heatmaps and summarised botanical value map provide complete coverage for England, as defined by the Ordnance Survey (Ordnance Survey, 2021).

8.3 Product spatial resolution

The OS grid cells are used to create the spatial frameworks at the 100 x 100 m resolution for the RST plant species heatmap and 1 x 1 km resolution for the other botanical heatmaps and botanical value map. The summarised botanical value map is provided as a shapefile, and the botanical heatmaps as geopackages.

8.4 Data attributes

For each of the botanical heatmaps and summarised botanical value map, a series of data attributes are provided. Appendix 1: Botanical heatmap and botanical value map data attributes details the name, data type and a description of the attributes associated with each monad or hectare.

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Appendix 1: Botanical heatmap and botanical value map data attributes

Ancient Woodland Indicator (AWI) botanical heatmap 2021

AWI Polygon vector layer:

Field	Full name	Data type	Description
monad	monad	String	Unique 1km OS grid reference
region	region	String	Regional division the monad sits within
RDays_40	recorder days (>=40 taxa)	Integer	Recorder days where over 40 taxa have been recorded on a single list on a single day by an individual recorder.
surveyCov	Survey coverage	String	Based on the number of recorder days, either ‘good survey coverage’ where 3 or more recorder days, or ‘poor survey coverage’ where less than 3 recorder days observed.
totAWI	total number of Ancient woodland indicators	Integer	Total number of ancient woodland indicators recorded within the monad between 1970 and 2021

AWI species table:

Field	Full name	Data type	Description
monad	monad	String	Unique 1km OS grid reference
species	species	String	Latin name for the species recorded
commonName	common name	String	Common name for the species recorded
lastRecorded	last recorded	Integer	Year of the last record for the species within the monad

Botanical heatmaps 1km 2021

Botanical Heatmap polygon layer:

Field	Full name	Data type	Description
monad	monad	String	Unique 1km OS grid reference
region	administrative region	String	Regional division the monad sits within
RDays_40	recorder days (>=40 taxa)	Integer	Recorder days where over 40 taxa have been recorded on a single list on a single day by an individual recorder.
surveyCov	Survey coverage	String	Based on the number of recorder days, either ‘good survey coverage’ where 3 or more recorder days, or ‘poor survey coverage’ where less than 3 recorder days observed.
RSTsp	total number of RST species	Integer	Total number of Rare, Scarce and Threatened (RST) plant species recorded in the monad
GB_Rare	GB rare species	Integer	Number of RST species with a GB rare status
GB_Scarce	GB scarce species	Integer	Number of RST species with a GB scarce status
allHabs	all PHPI species	Integer	Total number of Priority Habitat Positive Indicator (PHPI) species, combined across all habitat types
arable	arable	Integer	Number of PHPI species associated with arable habitats

boundary	boundary	Integer	Number of PHPI species associated with boundary habitats
coastal	coastal	Integer	Number of PHPI species associated with coastal habitats
fenMarshSwamp	fen, marsh and swamp	Integer	Number of PHPI species associated with fen, marsh and swamp habitats
freshwater	freshwater	Integer	Number of PHPI species associated with freshwater habitats
grassland	grassland	Integer	Number of PHPI species associated with grassland habitats
heathBog	heath and bog	Integer	Number of PHPI species associated with heath and bog habitats
inlandRock	inland rock	Integer	Number of PHPI species associated with inland rock habitats
montane	montane	Integer	Number of PHPI species associated with montane habitats
woodland	woodland	Integer	Number of PHPI species associated with woodland habitats

RST plant species table:

Field	Full name	Data type	Description
monad	monad	String	Unique 1km OS grid reference
species	species	String	Latin name for the species recorded
commonName	common name	String	Common name for the species recorded
GBstatus	GB status	String	Whether the species status is rare (NR) or scarce (NS) in GB
lastRecorded	last recorded	Integer	Year of the last record for the species within the monad

PHPI species table:

Field	Full name	Data type	Description
monad	monad	String	Unique 1km OS grid reference
species	species	String	Latin name for the species recorded
commonName	common name	String	Common name for the species recorded
lastRecorded	last recorded	Integer	Year of the last record for the species within the monad

Broad Habitat associated species table:

Field	Full name	Data type	Description
species	species	String	Latin name for the species recorded
commonName	common name	String	Common name for the species recorded
arable	arable	Integer	1 if associated with broad habitat type in Plantatt, 0 if not
boundary	boundary	Integer	1 if associated with broad habitat type in Plantatt, 0 if not
coastal	coastal	Integer	1 if associated with broad habitat type in Plantatt, 0 if not
fenMarshSwamp	fen, marsh and swamp	Integer	1 if associated with broad habitat type in Plantatt, 0 if not
freshwater	freshwater	Integer	1 if associated with broad habitat type in Plantatt, 0 if not
grassland	grassland	Integer	1 if associated with broad habitat type in Plantatt, 0 if not
heathBog	heath and bog	Integer	1 if associated with broad habitat type in Plantatt, 0 if not
inlandRock	inland rock	Integer	1 if associated with broad habitat type in Plantatt, 0 if not

montane	montane	Integer	1 if associated with broad habitat type in Plantatt, 0 if not
woodland	woodland	Integer	1 if associated with broad habitat type in Plantatt, 0 if not

Rare, Scarce and Threatened (RST) plant species heatmap 100m 2021

RST plant species heatmap polygon layer:

Field	Full name	Data type	Description
hectare	hectare	String	Unique 100m grid square reference
region	region	String	Regional division the monad sits within
RSTsp	total RST species	Integer	Total number of Rare, Scare and Threatened plant species recorded in the hectare
GB_Rare	GB rare species	Integer	Number of RST species with have a GB rare status
GB_Scarce	GB scarce species	Integer	Number of RST species with have a GB scarce status

RST plant species table:

Field	Full name	Data type	Description
hectare	hectare	String	Unique 100m grid square reference
species	species	String	Latin name for the species recorded
commonName	common name	String	Common name for the species recorded
lastRecorded	last recorded	Integer	Year of the last record for the species within the monad

Botanical value map 2021

Field	Full name	Data type	Description
monad	*monad*	String	Unique 1km grid square reference
surveyCov	Survey coverage	String	Based on the number of recorder days, either 'good survey coverage' where 3 or more recorder days, or 'poor survey coverage' where less than 3 recorder days observed.
RSTsp	*RST species value category*	String	Value category for Rare, Scarce and Threatened (RST) species (high, moderate, low, further survey required)
arable	*arable*	String	Value category for arable habitats (high, moderate, low, further survey required)
boundary	*boundary*	String	Value category for boundary habitats (high, moderate, low, further survey required)
coastal	*coastal*	String	Value category for coastal habitats (high, moderate, low, further survey required)
fenMarshSwamp	*fen, marsh, swamp*	String	Value category for fen, marsh and swamp habitats (high, moderate, low, further survey required)
freshwater	freshwater	String	Value category for freshwater habitats (high, moderate, low, further survey required)
grassland	grassland	String	Value category for grassland habitats (high, moderate, low, further survey required)
heathBog	heath and bog	String	Value category for heath and bog habitats (high, moderate, low, further survey required)
inlandRock	inland rock	String	Value category for inland rock habitats (high, moderate, low, further survey required)
montane	montane	String	Value category for montane habitats (high, moderate, low, further survey required)

woodland	woodland	String	Value category for woodland habitats (high, moderate, low, further survey required)
valueCat	overall value category	String	Overall value category (high, moderate, low, further survey required).

Appendix 2: Local benchmarking analysis

To assess the habitat quality of monads we quantified the number of Priority Habitat Positive Indicator (PHPI) species recorded present. These PHPI species combined three groups of species indicative of high-quality habitats: (1) BSBI axiophytes, (2) positive indicators for Common Standards Monitoring guidance for SSSIs and (3) ancient woodland indicators. Each species was assigned to 10 broad habitats and then the number of PHPI species in each broad habitat within a monad was compared to all the PHPI species within that habitat within the surrounding area. We trialled these proportions within three types of 'local benchmarking' namely:

1. The OS administrative regions
2. the 100 x 100 km grid cells (myriad)
3. a moving neighbourhood of surrounding monads

Regional indicator benchmarking

For each of the nine regional divisions in England, shown in Figure 1, the total number of unique PHPI species associated with a particular broad habitat was extracted. These were then assessed by 1) individual broad habitat to explore how the regional pools differed and 2) the number of species which would be used at different proportionate benchmarks, e.g., benchmarking where the monad contained at least 10% of the regional pool of indicators. Table 1 shows an example of these regional differences in indicators for each of the ten broad habitat classes.

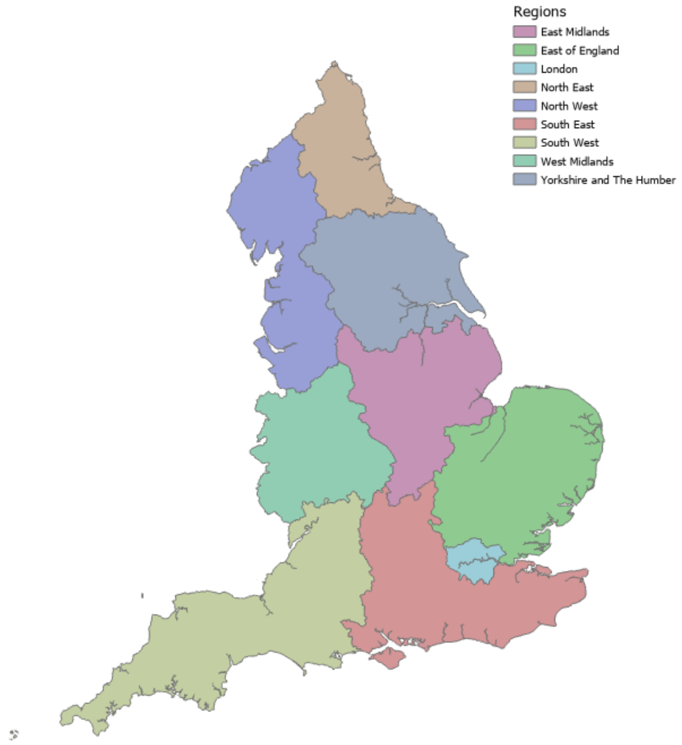

Figure 1: A map of the ONS (2020) administrative regions across England. Source: Office for National Statistics licensed under the Open Government Licence v.3.0. Contains OS data © Crown copyright and database right [2020].

Table 1: The regional total number of positive habitat indicators associated with each broad habitat class, recorded per monad (1 x 1 km) across England.

Region	Arable	Boundary	Coastal	Fen, Marsh, Swamp	Freshwater
North East	55	147	105	175	132
North West	59	156	114	184	153
Yorks & Humber	69	165	96	177	144
East Midlands	69	165	108	162	142
West Midlands	68	165	59	154	141
South West	77	178	134	164	151
South East	77	180	127	165	157
East of England	76	171	119	166	145
London	64	151	69	132	128

Region	Grassland	Heath & Bog	Inland Rock	Montane	Woodland
North East	269	66	155	38	182
North West	274	71	176	53	192
Yorks & Humber	282	60	163	35	192
East Midlands	272	53	144	17	181
West Midlands	253	59	149	16	196
South West	289	76	158	13	201
South East	290	69	127	9	194
East of England	278	58	120	8	182
London	238	38	107	8	164

Different proportions were then trialled for classifying habitat quality for each monad. Figure 2 shows an example of these, with the different maps output through varying the proportion thresholds. From these maps, discussions with BSBI experts found that a benchmark of around 20% of the regional pool of PHPI species present seemed a reasonable boundary for determining a high value monad, highlighting key areas on the map which are expected to be of high importance, such as the Peak District, areas in the North Pennines, and Dartmoor.

Assessing botanical value by region demonstrated a lot of variation both with region and with habitat type, with the most high-value monads flagged for woodland indicators. The same proportional benchmark was applied across all habitats with Table 2 using thresholds of 10% for the low-moderate divide and the high value class representing monads with where over 20% of regional indicators were present.

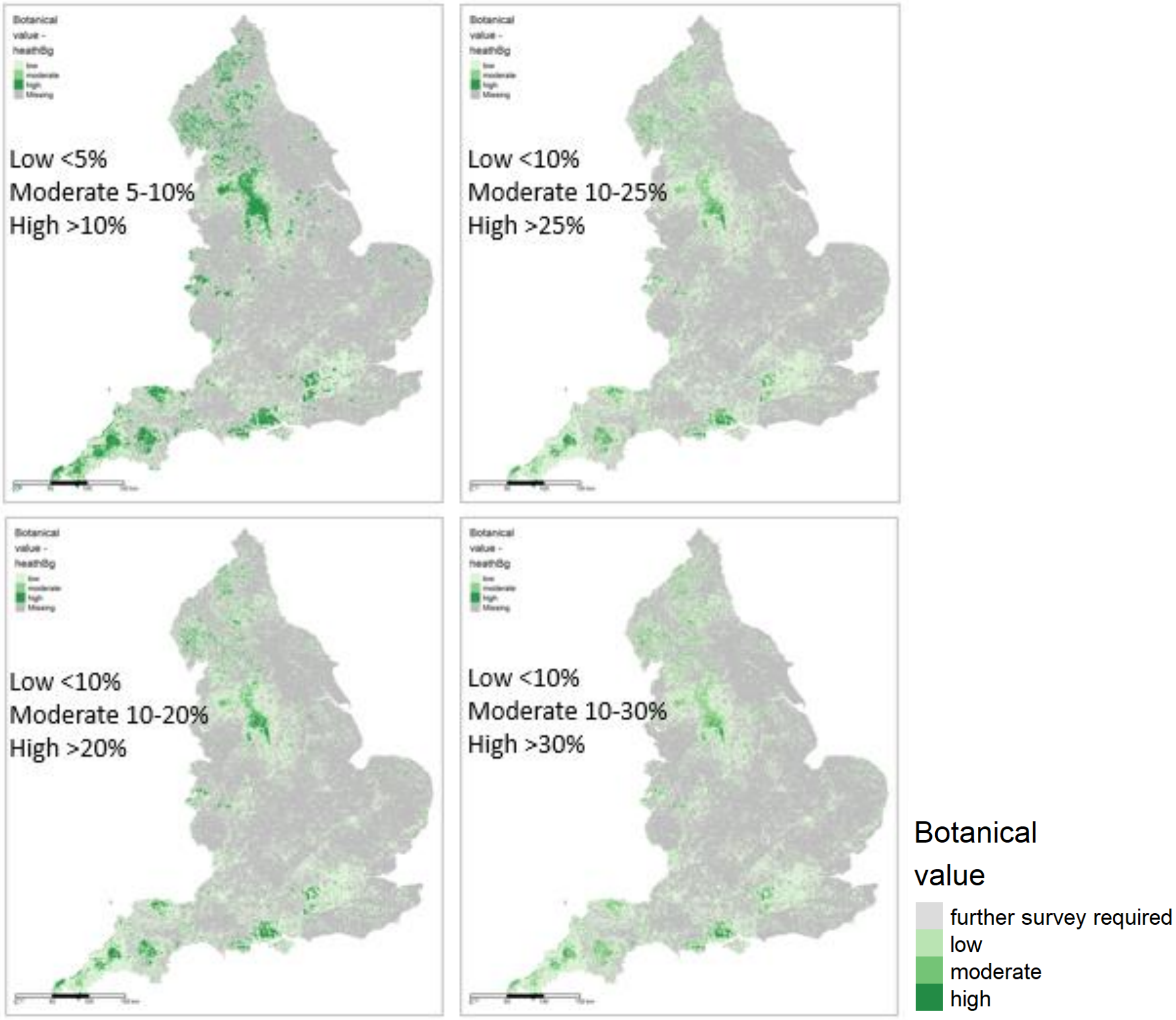

Figure 2: Maps showing the differing outputs produced through varying the proportion thresholds between the low, moderate, and high categories for botanical value. © Copyright Natural England & Botanical Society of Britain and Ireland. Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

Table 2. The number of monads classified within each value category by broad habitat type.

Habitat	High	Moderate	Low	Further Survey Required
Arable	229	17712	60484	52991
Boundary	3147	29461	71518	29290
Coastal	1127	2291	58499	71499
Fen, marsh & swamp	6178	18414	72804	336020
Freshwater	1558	9767	80191	41900
Grassland	5107	26336	74046	27927
Heath & bog	2969	6001	38944	85502
Inland rock	982	14704	80397	37333
Montane	427	5819	32094	95076
Woodland	15265	27423	61459	29269

Myriad indicator benchmarking

The OS myriad (100 x 100 km grid cell) boundaries were first spatially joined to the OS monads (1 x 1 km grid cells) in a reference table. An example diagram is illustrated in Figure 3.

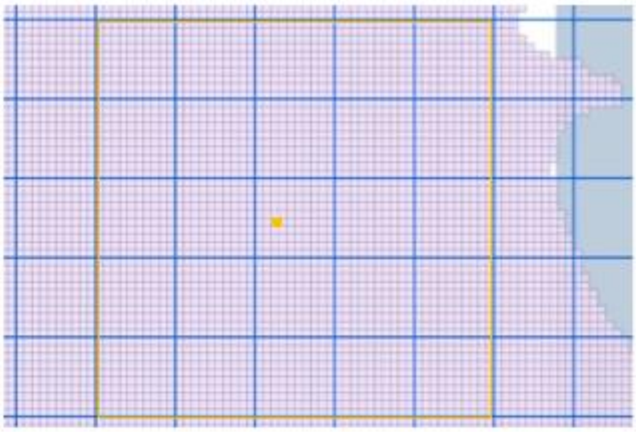

Figure 3: A diagram illustrating the myriad approach, where the filled yellow grid square represents the selected monad and the surrounding yellow square representing the wider OS myriad. Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

For each monad, the associated myriad was extracted alongside all the other monads which fell within the same myriad. These were then used in a similar approach to the regional indicator benchmarking to compare for each monad and each habitat type, the number of indicators present in relation to the total number of indicators found within the wider myriad pool. Two sets of proportion thresholds were trialled:

- Trial 1: Low <5%, Moderate 5-10%, High > 10%
- Trial 2: Low <10%, Moderate 10-20%, High > 20%

This yielded similar results to the regional boundaries with overall fewer monads falling within the moderate categories. The results from these tests for heath and bog are shown in Figure 4 for comparison, and the proportional difference in the number of monads categorised into High, Moderate, Low and Further Survey Required are shown in Figure 5. For heath and bog, the trial 2 thresholds produced comparatively more monads in the higher value categories compared with the regional indicator benchmarking, with 3953 monads classed as High, and 6,112 monads classed as Moderate. This method is somewhat more limited where coastal monads would be pooling from a smaller number of monads than those inland. Therefore, if coastal coverage is poor this could have a large impact on the range of values within the surrounding myriad.

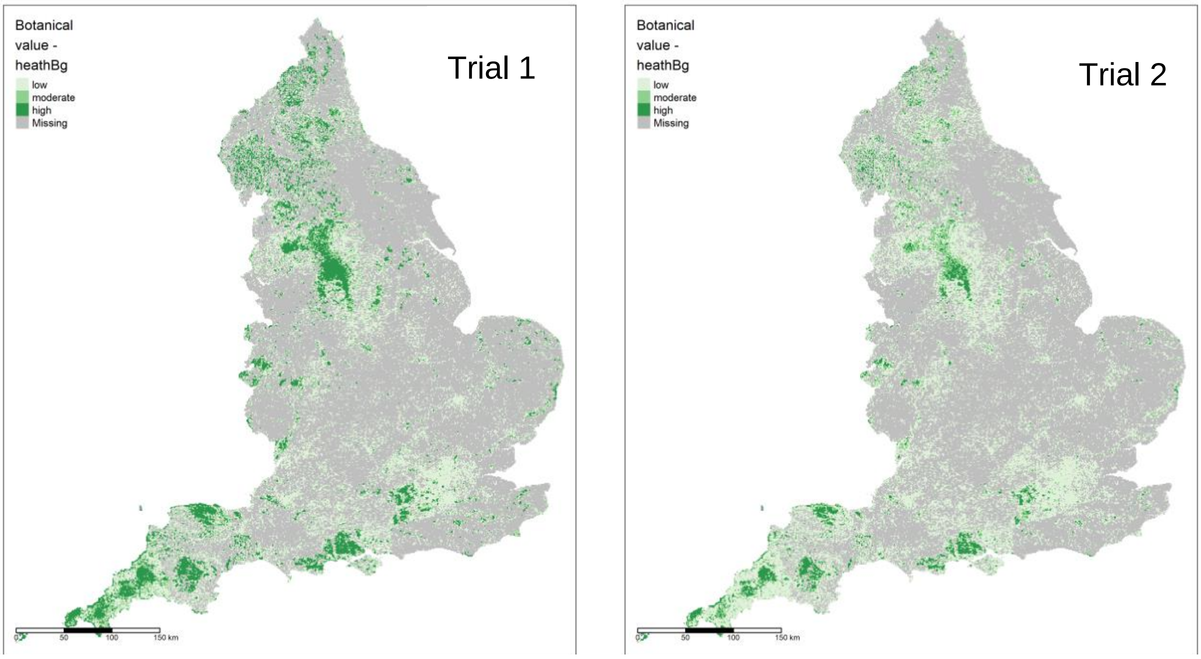

Figure 4: Maps of the habitat quality based on the presence of heath and bog species indicators, mapped through benchmarking monads on the proportion of indicators present compared to the indicator pool of the tetrad. Trial 1 on the left uses 5% and 10% thresholds, whereas Trial 2 on the right uses higher thresholds of 10% and 20% for the Low, Moderate and High categories.

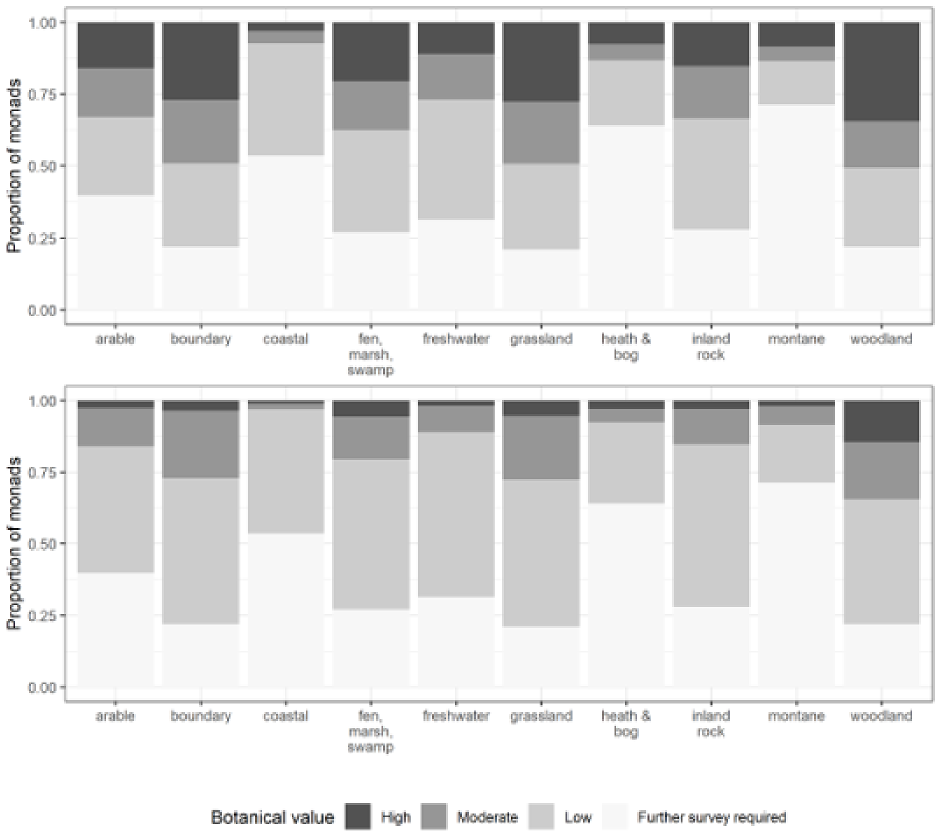

Figure 5: The proportion of monads categorised into High, Moderate and Low classes compared with those requiring further survey. The results are for trial 1 (top) with the comparatively lower thresholds with trial 2 (bottom).

Moving neighbourhood benchmarking

Finally, we tested a ‘moving neighbourhood’ analysis, whereby the species pool was extracted from neighbouring monads within a defined distance of the assessed monad. For each monad, the centroid was first extracted and then buffered to the specified distance, with half the length of a monad removed to ensure only monads which fell within the distance boundary were selected. The equation for calculating this was:

$$\text{Buffer Distance} = x * 1000 + (1000/2)$$

where x is the moving neighbourhood radius in kilometers.

The buffered area was then used to extract all the neighbouring monads which fell within the surrounding neighbourhood of the assessed monad. Figure 6 demonstrates a diagram of this process for establishing the moving neighbourhood of monads.

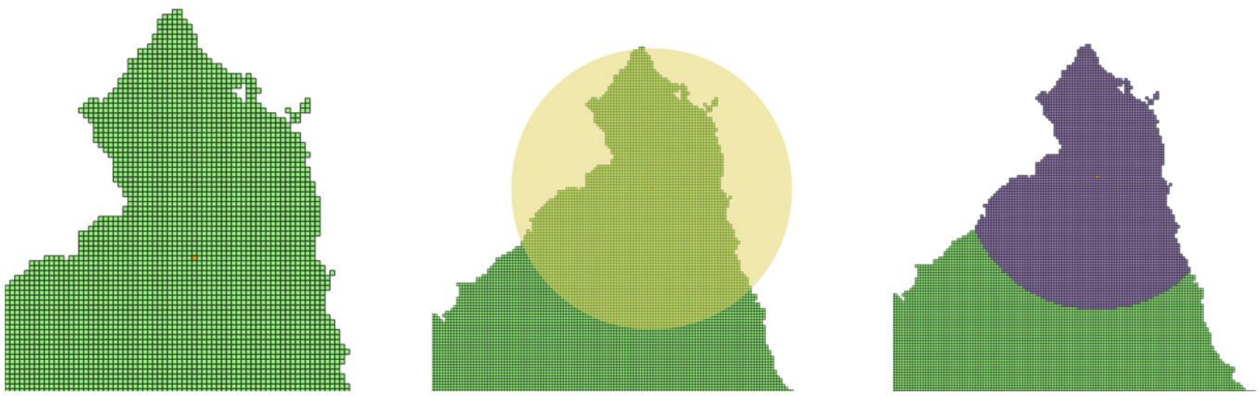

Figure 6: A diagram showing the process of selecting the moving neighbourhood of monads which is used to retrieve the species pool around a monad. Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

As before, the total number of species were then summarised for the neighbourhood of monads and proportions of this total was used for benchmarking. This was computationally more expensive compared to the previous methods and again had the edge effect where coastal areas would have comparatively less monads to establish the benchmark compared with inland monads.

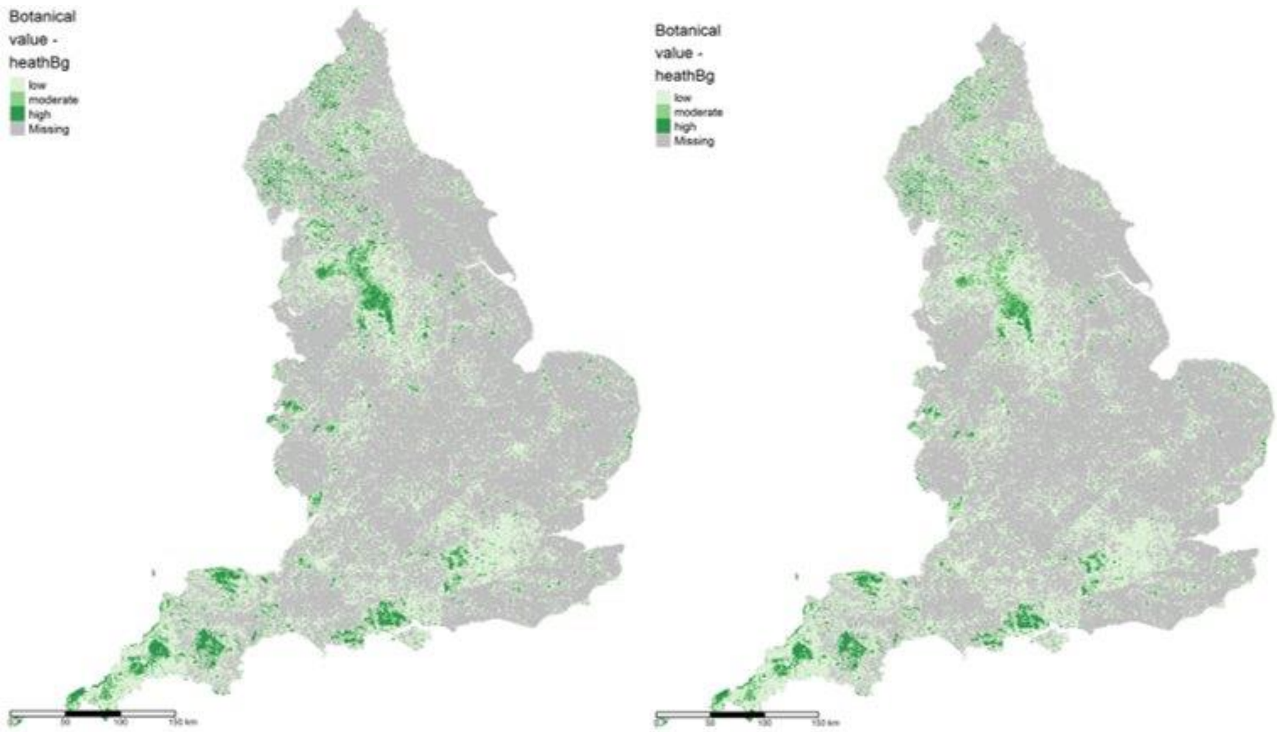

Figure 7. Maps of the categorised value of according to the presence of heath and bog positive habitat indicators between 1970 and 2021. (left) neighbourhood radius of 25 km, (right) neighbourhood radius of 50 km. © Copyright Natural England & Botanical Society of Britain and Ireland. Map attribution: Contains OS data © Crown copyright and database right 2021. Source: Office for National Statistics under Open Government Licence v.3.0.

Moving neighbourhoods with radius distances of 25km and 50km were trialled. Both distance radius trials demonstrated a similar distribution of results as shown in Figure 7, however, the smaller radius of 25 km showed a greater refinement in the results with more monads in the moderate and high categories. This was noted as being more likely to capture the intricacies of the regional differences in indicator present, whereas 50km was deemed too coarse. For heath and bog, the 25 km moving neighbour produced a summarised botanical value map with 5,333 monads categorised as high value, 6,858 as moderate value and 35,723 as low value.

Conclusion

Out of the trialled methods, the 25 km moving neighbourhood yielded the greatest number of monads categorised as being of high and moderate botanical value. Discussions with the Natural England’s habitat specialists and BSBI botanical experts agreed this methodology seemed most suitable for alleviating some of the spatial bias in indicator presence and was in line with previous studies adopting a similar methodology.

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