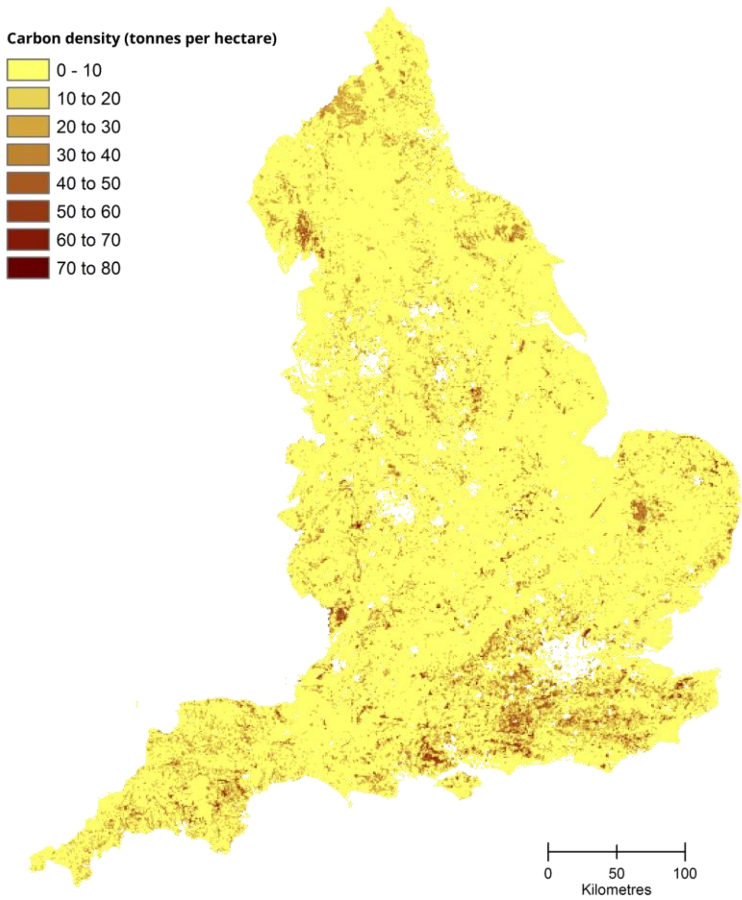
Carbon in vegetation

Mean estimates of above-ground carbon stocks (t/ha)



Carbon in vegetation
Mean estimates of above-ground carbon density in vegetation (tonnes per hectare).

What does this map show?

Mean estimates of carbon stocks, in tonnes per hectare, stored in above-ground vegetation. Soil carbon is known to be the biosphere's largest carbon reservoir, but forests and other vegetation can also make up large proportions of the total carbon pool. Changes in size and productivity of the above-ground carbon pool may act as a sink or source for carbon dioxide. As such, the carbon stored in vegetation plays a vital role in climate regulation.

Interest lies in increasing the net amount of carbon stored in these natural pools. The amount, and geographical distribution, of carbon in vegetation (especially forests) is of considerable importance to this.

Above-ground carbon in vegetation has high spatial variation and closely follows the geographic distribution of forests and woodland across England, hence why there is a greater density of above-ground carbon in the south and east, e.g. The New Forest and Thetford Forest. This is because woodlands contain by far the greatest amount of carbon across all vegetation types. Other vegetation types such as heathland also have greater above ground carbon and are reflected in the map.

How was this map produced?

This map was produced using estimates of the average amount of carbon stored in each land cover type and upscaling to a full England coverage, based on the estimated spatial distribution of land cover across England [1]. Estimates of carbon in tonnes per hectare, for each land cover category (other than broadleaf and coniferous woodland) were based on an extensive literature search [2,3,4]. Carbon density for woodlands was based on more species and age specific estimates [2], as these are known to greatly affect the amount of carbon stored. The net carbon density for each tree species was estimated based on the total area coverage of the different age classes for that species across England [5]. This was used together with information on the spatial distribution of each species, estimated from Countryside Survey field data [6], to produce estimates of total carbon stock in discrete spatial units across England.

Having obtained the total stock in woodlands, a map of woodland coverage was used to create a carbon density map for woodlands, which was then summed with the carbon estimates from other vegetation types to produce a full England map of carbon (t/ha) stored in above ground vegetation.

What are the limitations of this map?

1. The carbon stored in each vegetation type is not directly measured, it is based on searching results in the academic literature that offer biomass carbon conversion equations [2].

2. Estimates of uncertainty are not available. This is because the uncertainty in the estimated age and species distribution of woodland trees is not known. Data from the woodland inventory of Great Britain [5] was used to produce these values and the inventory does not produce uncertainty estimates for these statistics. Our map could therefore not usefully produce any uncertainty in the estimated carbon density.

3. The map shows mean values at a 1 km square resolution.

4. The values for each 1 km square are generated based on literature searches and estimated values of carbon density in land cover categories and upscaling using a satellite-based land cover product. Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. Estimates of carbon density for each land cover category (other than woodland) were estimated based on an extensive literature search [2,3,4].

2. Net carbon density for each woodland species was estimated based on age-specific carbon density estimates for that species [2] and weighted by the nationwide distribution of age classes for the species [5].

3. The proportion of each woodland species in a landclass area [7] was estimated based on intensive field survey habitat mapping [6]. A total carbon stock stored in woodland vegetation for each landclass was estimated from the species-specific net density estimates and the proportion of the species within the landclass.

4. The total carbon stored within woodland vegetation within a landclass was then distributed based on where the woodland vegetation occurs according to Land Cover Map 2007 [1]. This provided a 1km pixel map of carbon density stored in woodlands.

5. The carbon density contribution from each non-woodland broad habitat land cover type, based on the literature search, was assigned to all areas of England where the broad habitat occurred, using Land Cover Map 2007 [1].

6. The Carbon density stored in woodland and in other vegetation was summed to provide a total carbon density map across England.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

You must cite:

> Henrys, P.A.; Keith, A.; Wood, C.M. (2016). Model estimates of aboveground carbon for Great Britain. NERC Environmental Information Data Centre. http://doi.org/10.5285/9be652e7-d5ce-44c1-a5fc-8349f76f5f5c

References

1. Morton, R.D.; Rowland, C.S.; Wood, C.M.; Meek, L.; Marston, C.G.; Smith, G.M. (2014). Land Cover Map 2007 (1km dominant target class, GB) v1.2. NERC Environmental Information Data Centre. http://doi.org/10.5285/6cffd348-dad7-46f9-9c5b-8d904dd5b2a2

2. Milne, R., Brown, T. A. (1997). Carbon in the vegetation and soils of Great Britain. Journal of Environmental Management, 49(4), 413-433.

3. Adger, N., Brown, K., Sheil, R., Whitby, M. (1991). Dynamics of land use change and the carbon balance. Working Paper No. 15, Countryside Change Unit, University of Newcastle upon Tyne.

4. Olson, J. S., Watts, J. A., Allison, L. J. (1985). Carbon in live vegetation of major world ecosystems. Oak Ridge National Laboratory Publication ORNL-5862. Report to the U.S. Department of Energy, Contract No. W-7405-eng-26.

5. Smith, S., Gilbert, J. (2003). National Inventory of Woodland & Trees. Forestry Commission, Edinburgh.

6. Maskell, L.C., Norton, L.R., Smart, S.M., Carey, P.D., Murphy, J., Chamberlain, P.M., Wood, C.M., Bunce, R.G.H., Barr, C.J (2008). Countryside Survey Technical Report No.01/07: Field Mapping Handbook. Centre for Ecology & Hydrology.

7. Bunce et al. (2007) ITE land classification of Great Britain 2007. http://doi.org/10.5285/5f0605e4-aa2a-48ab-b47c-bf5510823e8f

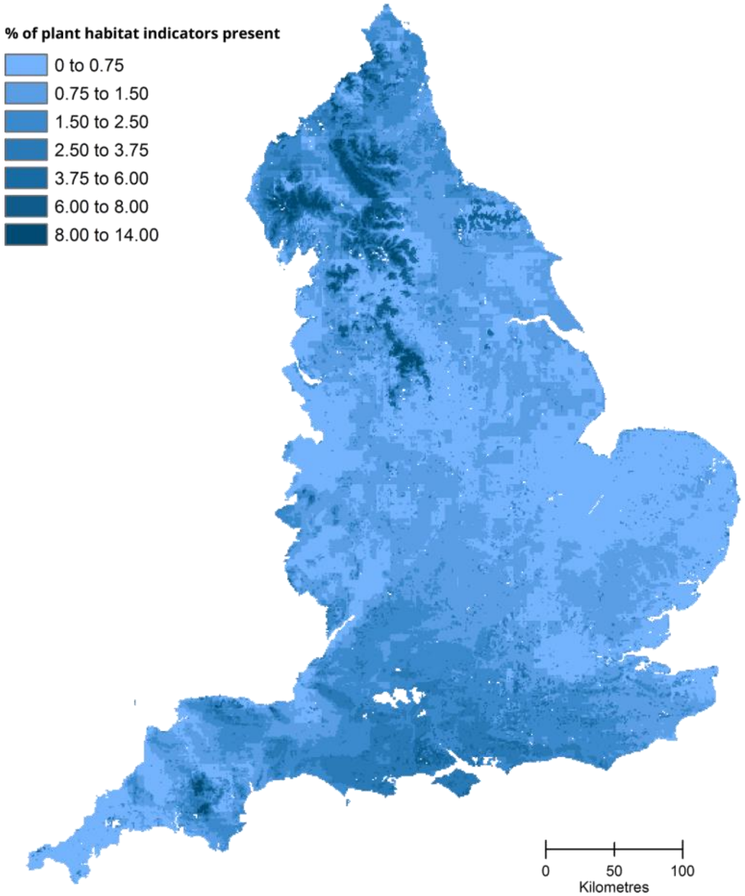
NATURAL ENGLAND

Centre for Ecology & Hydrology

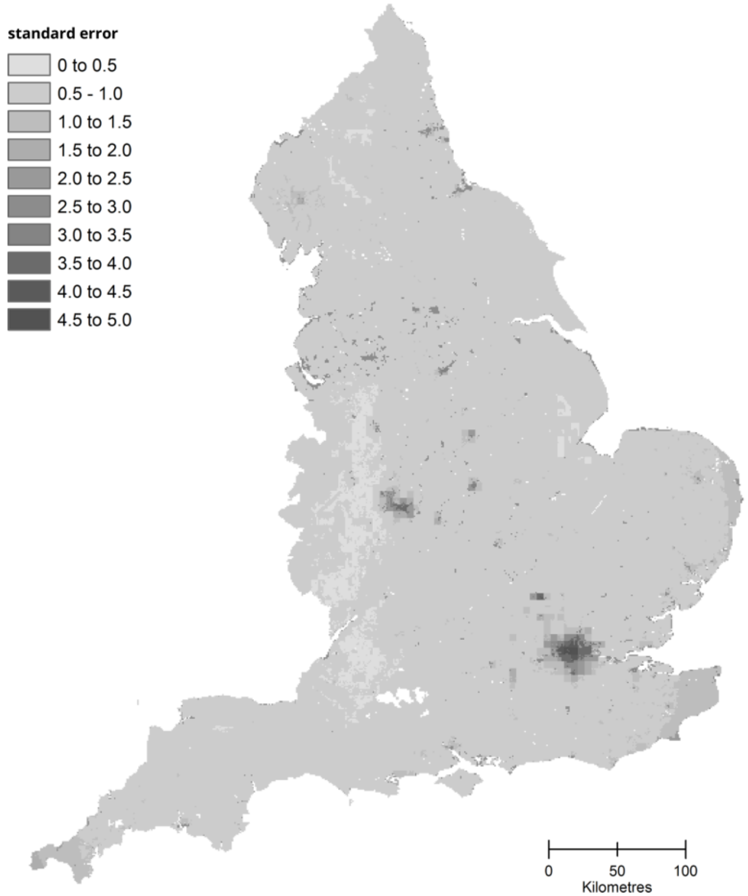
NATURAL ENVIRONMENT RESEARCH COUNCIL

Plant indicators for habitats in good condition

Mean estimates of expected plant habitat indicators (% of plant habitat indicators present)



Uncertainty: Standard error from the mean estimates



Plant indicators for habitats in good condition

Mean estimates of expected plant habitat indicators measured as percentage of plant habitat indicators present.

What does this map show?

The expected plant indicators for habitats in good condition map is based on the occurrence of plant species that are positive indicators for different habitats. The indicator species are taken from the Common Standards Monitoring guidance for Sites of Special Scientific Interest [1], so are based on habitats of high conservation value. They represent species that are characteristic of habitats which are in good condition. Total plant species richness can be deceptive as a measure of biodiversity, higher species numbers may be an indicator of nutrient enrichment or disturbance. Additional species may be out of place and indicate poor condition. By using species that are agreed positive indicators, or 'characteristic' species, and calculating a proportion between the observed plant diversity and the potential indicators within that habitat type, a better understanding is gained of habitat condition and the nature of the plant diversity. Positive habitat indicators are useful in providing information on ecosystem health and the capacity to maintain supporting or regulatory ecosystem services. They are also a cultural service measure, as a number of the species are 'desirable', aesthetic, culturally important species associated with particular habitat types.

The map shows that there are higher proportions of positive indicator species in northern England and upland areas. Upland areas contain habitats such as bog, heathland, acid grassland which are less intensively managed, still retain significant numbers of indicator species and can cover large areas. Areas of higher richness in the south of England may reflect the distribution of other priority habitat types such as calcareous grassland.

How was this map produced?

This map was produced by using the proportion of positive habitat indicators for each 2m × 2m plot in the Centre for Ecology & Hydrology Countryside Survey (2007). There were 8278 sample locations, across GB within 591 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on relationships between the proportion of positive habitat indicators and environmental variables which affect their distribution: broad habitat type, geology, temperature, precipitation and nitrogen and sulphur deposition. The relationship between habitat indicators and the presence of a Site of Special Scientific Interest designation was also used in the extrapolation.

What are the limitations of this map?

1. Areas such as urban and littoral rock are not sampled by Countryside Survey and therefore have no associated data. These areas are shown in white on the map.

2. The map shows mean values at a 1 km square resolution. The standard error attributed to the mean estimates is only valid at 1km square resolution. The standard error at different resolutions is unknown.

3. The values for each 1 km square are generated from a statistical model of samples from approximately 591 1 km squares. Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. A list of positive habitat indicators [10] was compiled based on the Common Standards Monitoring guidance in association with the Botanical Society of the British Isles [2,3].

2. Data is taken from Countryside Survey 2007 which surveyed 591 1km squares as part of a stratified random sample across Great Britain. This was stratified by land class based on topography, geology, soils and climate [4]). A series of 2m × 2m vegetation plots was located within each 1 km square [5]. Each vegetation plot was assigned to a broad and priority habitat type [6,7]. Within each vegetation plot all vascular plants were recorded (nomenclature followed [8,9]). For this analysis only area plots were used, rather than plots from linear features, such as hedges.

3. The number of positive indicator species in each vegetation plot was calculated using the list mentioned above. The habitat classification of each plot was used to choose the indicators, so that, for example, heathland indicator species were used for heathland plots. The proportion of positive indicator species was calculated by dividing the count by the total number of positive indicator species that could have been recorded for that habitat.

4. Using a statistical model (a generalized additive model), a mean estimate of the proportion of positive indicator species for each habitat, was extrapolated across the whole of England. This extrapolation was based on the proportion of positive indicators associated with a number of variables: broad habitat type (the dominant broad habitat in each 1km square was used for the model), geology, temperature, precipitation and nitrogen and sulphur deposition, as well as the presence or absence of a Site of Special Scientific Interest designation.

5. The statistical model was also used to produce an associated standard error map. High values reflect high variability and hence greater uncertainty in the mean estimates.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

You must cite:

> Maskell, L.; Henrys, P.; Norton, L.; Smart, S. (2016). Model estimates of expected diversity of positive plant habitat condition indicators. NERC Environmental Information Data Centre. http://doi.org/10.5285/cc5ae9b1-43a0-475e-9157-a9b7fccb24e7

References

1. Smart, S., Dunbar, M.J., Emmett, B.A., Marks, S., Maskell, L.C., Norton, L.R., Rose, P., Simpson, I.C. (2010). An Integrated Assessment of Countryside Survey data to investigate Ecosystem Services in Great Britain. Technical Report No. 10/07 NERC/Centre for Ecology & Hydrology 230pp. (CEH Project Number: C03259).

2. JNCC, Guidance for Common Standards Monitoring (CSM) http://jncc.defra.gov.uk/page-2199 accessed 16th March 2016

3. JNCC, (2004). Common Standards Monitoring Guidance for Vascular Plants, Version February 2004, ISSN 1743-8160

4. Bunce et al. (2007). ITE land classification of Great Britain 2007 http://doi.org/10.5285/5f0605e4-aa2a-48ab-b47c-bf5510823e8f

5. Smart, S.M., Maskell, L.C., Norton, L.R., Scott, R., Carey, P.D., Murphy, J., Chamberlain, P.M., Wood, C.M., Bunce, R.G.H. and Barr, C.J. (2008). Vegetation plots handbook. Technical Report No.2/07/NERC/Centre for Ecology and Hydrology 64pp, http://countrysidesurvey.org.uk/sites/default/files/pdfs/reports2007/CS_UK_2007_TR2.pdf

6. Jackson, D. (2000). Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. JNCC report 307

7. Maskell, L.C., Norton, L.R., Smart, S.M., Carey, P.D., Murphy, J., Chamberlain, P.M., Wood, C.M., Bunce, R.G.H. and Barr, C.J. (2008). Field mapping Handbook. Technical Report No.1/07/NERC/Centre for Ecology and Hydrology 143pp http://countrysidesurvey.org.uk/sites/default/files/pdfs/reports2007/CS_UK_2007_TR1.pdf

8. Stace, C. (1997). New Flora of the British Isles. Cambridge University press, Cambridge 2nd edition.

9. Watson, E. (1981). British Mosses and Liverworts. Cambridge University Press, Cambridge.

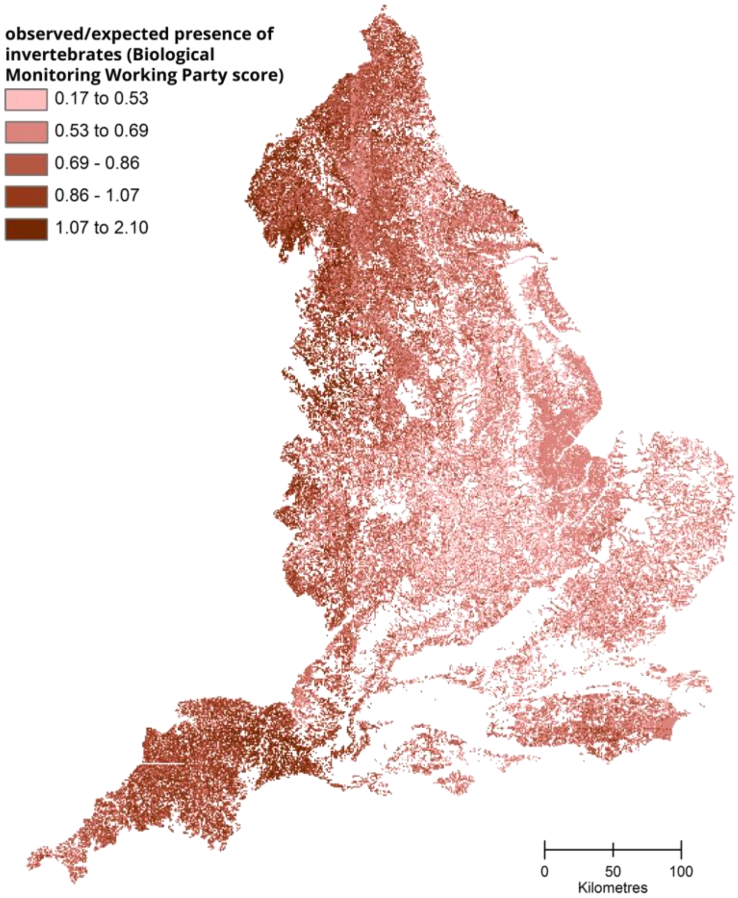
10. Species indicator list *(derived from Hill, M.O.; Preston, C.D.; Roy, D.B. (2004). PLANTATT - Attributes of British and Irish Plants - Spreadsheet. Centre for Ecology & Hydrology)*. http://eip.ceh.ac.uk/naturalengland-ncmaps/reports/plantindicators_spplist.

NATURAL ENGLAND

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Headwater stream quality

Invertebrates in headwater streams



Headwater stream quality
Measured by comparing predicted observed/expected presence of invertebrates (Biological Monitoring Working Party score)

What does this map show?

Freshwater invertebrates vary in their sensitivity or tolerance of nutrient enrichment and therefore the communities of invertebrates present in headwater streams provide good indicators of water quality. This map shows a comparison of the observed and expected presence of invertebrate indicator species in headwater streams, based on Biological Monitoring Working Party (BMWP) scores. The BMWP score is an index for measuring the biological quality of rivers using selected families of invertebrates as biological indicators [1]. A higher value on the map indicates that the water quality of headwater streams, as shown by the invertebrates, is better.

Headwater streams are generally upstream of Environment Agency water quality monitoring points for the Water Framework Directive. This map therefore tells us about the water quality in the smallest streams at the tops of river catchments.

The UK National Ecosystem Assessment (UKNEA 2011) recognises the importance of freshwater invertebrates as a component of natural capital and part of complex food webs which support fish and plant production, breaking down detritus and algae and ultimately contributing to improved water quality. Invertebrates which live part of their lives in water and part as flying insects also contribute to terrestrial food webs.

The map seems to show a differentiation between higher water quality in semi-natural landscapes and lower water quality in areas subject to more intensive agricultural management. No standard error map is provided with the approach taken here due to the complexity involved in interpreting errors as part of a ratio, or comparison.

How was this map produced?

This map was produced using observed/expected BWMP scores from headwater stream invertebrate samples, taken at 478 headwater stream sites across two survey years in the CEH Countryside Survey [2] (1998 and 2007). From the invertebrates collected, observed BMWP scores were calculated for each sample site. Expected BMWP scores were calculated for "reference" invertebrate communities, based on the physical characteristics of the sampled sites. Predictions were extrapolated up to a national level using statistical analysis.

What are the limitations of this map?

1. Areas not containing a headwater stream were not included in the models.

2. The map shows mean values at a 1 km square resolution.

3. The values for each 1 km square are generated from a statistical model of samples from 478 headwater stream sites across two survey years (1998 and 2007). Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. Headwater streams were identified based on Strahler order (1-3), see **Figure 1**.

2. Freshwater invertebrate samples were taken from 478 Countryside Survey sample locations in headwater streams using standard protocols [2] across two survey years (1998 and 2007).

3. Width, depth and substrate composition were recorded at each sample site.

4. The Biological Monitoring Working Party (BMWP) score (an index for measuring the biological quality of rivers using selected families of macroinvertebrates as biological indicators) [1] were calculated for each site (Observed BWMP).

5. An Expected BWMP score was calculated using the RIVPACS (River Invertebrate Prediction and Classification System) computer model. This model calculated an expected 'reference' macroinvertebrate community for each sample site, based on its physical characteristics.

6. For grid squares that were not sampled, 'Observed' BWMP scores were extrapolated to a national scale using a statistical model (Boosted Regression Tree) tested on the Countryside Survey data. This was based on the predicted relationships between catchment characteristics (altitude, slope, stream order, woody cover along streams, and % land cover of arable, improved grassland or urban) and water quality for a randomly generated river sampling site in each unmonitored 1km square.

7. Expected BWMP scores for un-monitored sites were calculated by assigning the RIVPACS scores to the randomly generated river sampling site in each unmonitored grid square, based on average land class [3].

8. Observed/Expected BWMP scores were calculated for each sample site

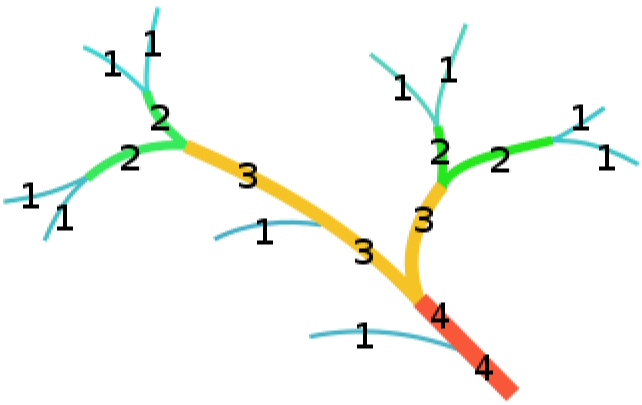


***Figure 1**. Diagram showing the Strahler stream order*

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

You must cite:

> Norton, L.; Dunbar, M.; Greene, S.; Scholefield, P. (2016). Headwater stream quality for Britain. NERC Environmental Information Data Centre. http://doi.org/10.5285/85e7beb6-e031-4397-a090-841b8c907d1b

References

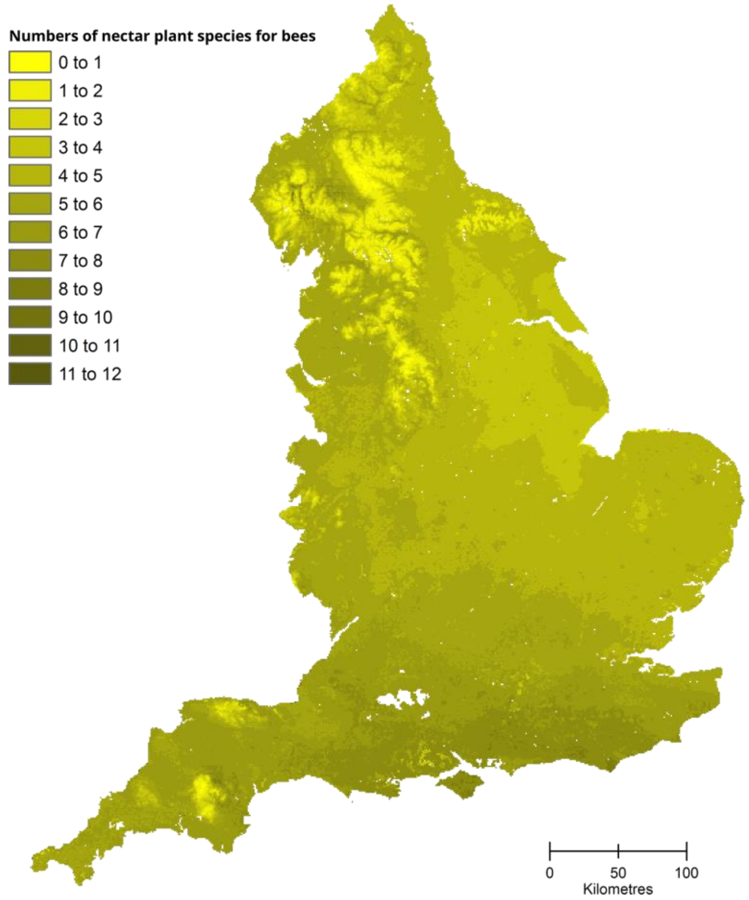
1. Armitage, P.D., Moss, D., Wright, J.F. et al. (1983). The performance of a new biological water-quality score system based on macroinvertebrates over a wide range of unpolluted running water sites. Water Research 17, 333-347.

2. Murphy, J., Weatherby, A. (2008). Freshwater Manual. Technical Report No.5/07/NERC/Centre for Ecology and Hydrology 71pp

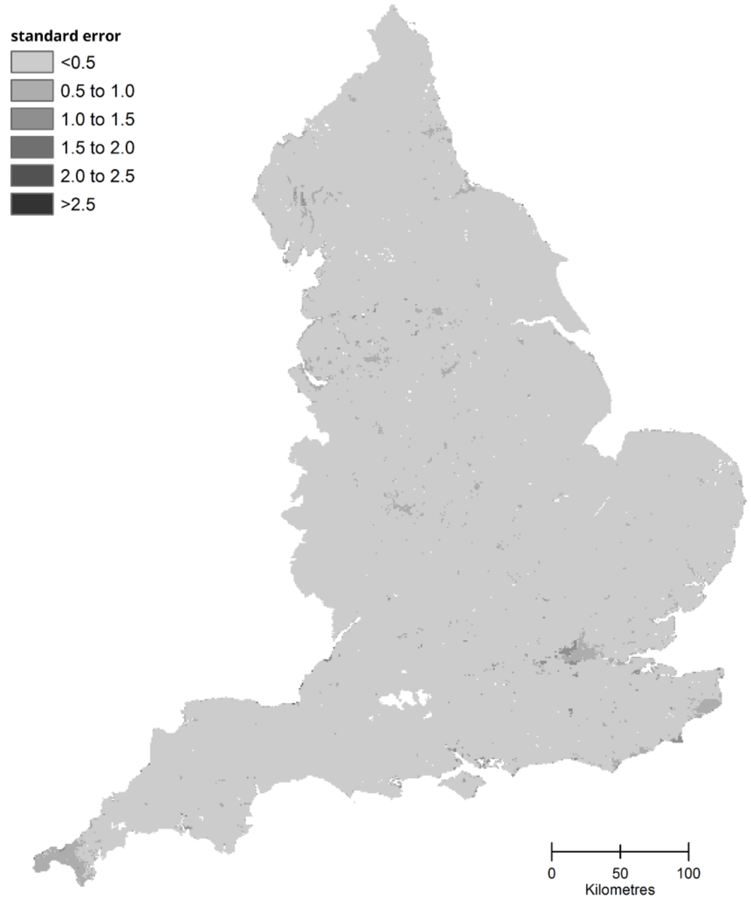
3. Bunce et al. (2007). ITE land classification of Great Britain 2007 http://doi.org/10.5285/5f0605e4-aa2a-48ab-b47c-bf5510823e8f

Nectar plant diversity for bees

Mean estimates of number of nectar plant species for bees per 2×2m plot



Uncertainty: Standard error from the mean estimates



Nectar plant diversity for bees

Mean estimates of bee nectar plant species richness measured as number of nectar plant species for bees per plot

What does this map show?

Mean estimates of numbers of nectar plant species for bees, in 2m × 2m vegetation plots.

The value of pollinators and pollination services is significant, both for food production and for wildflowers. Some crops are pollinated by managed imported bumblebee populations (e.g. strawberries, tomatoes), others are more effectively pollinated by wild pollinators (e.g. apples, field beans) and there is a significant requirement for service provision by wild pollinators [1]. Wildflowers make a significant contribution to cultural ecosystem services such as aesthetic value, and biodiversity and are dependent upon insect pollination. This map provides an important element of the natural capital relating to pollination: the distribution and abundance of nectar plants for bees across the landscape [2,3]. Studies have shown a causal link between declines in pollinators and declines in nectar producing plants [4], so a spatial representation of nectar plant distribution provides valuable information to aid protection of high quality pollinator habitat and provision of resilient landscapes.

This map shows that bee nectar plant richness is higher in the south, south west and through western England. This is likely to be related to habitat type (and hence climate and soil type), the highest richness of nectar plants tends to be in calcareous and neutral grasslands [5], although may also occur where there is high habitat diversity.

How was this map produced?

This map was produced by using the count of bee nectar plants per 2m x 2m vegetation plot in the Centre for Ecology & Hydrology Countryside Survey (2007), at 7408 sample locations, across Great Britain within 591 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on relationships between nectar plant species richness, broad habitat type, air temperature, nitrogen deposition, precipitation and altitude (as key variables affecting nectar plant richness).

What are the limitations of this map?

1. Areas such as urban and littoral rock are not sampled by Countryside Survey and therefore have no associated data. These areas are shown in white on the map.

2. The map shows mean values at a 1 km square resolution. The standard error attributed to the mean estimates is only valid at 1km square resolution. The standard error at different resolutions is unknown.

3. The values for each 1 km square are generated from a statistical model of samples from approximately 591 1 km squares. Hence the map does not show direct measurements at all locations.

4. The map was created by using broad habitat from the Land Cover Map., This means that only plots from areas of broad habitats were used, rather than linear features such as hedges. Linear features could be important sources of nectar plants particularly in more intensive landscapes. In future, when national data on linear habitats are available, it will be possible to scale up by linear habitats also.

Further detail on the steps for creating this map

1. Lists of nectar plant species for bumblebees and solitary bees were compiled through expert consultation and data analysis [2,6].

2. Data was taken from Countryside Survey 2007 which surveyed 591 1km squares as part of a stratified random sample across GB. This was stratified by land class which is based on topography, geology, soils and climate [7]. A series of 2m x 2m vegetation plots were located within each 1 km square [8]. Each vegetation plot was assigned to a broad and priority habitat type [9,10]. Within each vegetation plot all vascular plants were recorded (nomenclature followed [11]). For this analysis only area plots were used, rather than plots of linear features.

3. The number of nectar plant species in each 2m x 2m vegetation plot was calculated using the list mentioned above.

4. Using a statistical model (a generalized additive model), a mean estimate of nectar plant richness for each habitat, was extrapolated across the whole of England using the additional variables of air temperature, nitrogen deposition, precipitation and altitude.

5. The statistical model was also used to produce an associated standard error map. High values reflect high variability and hence greater uncertainty in the mean estimates.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

You must cite:

> Maskell, L.; Henrys, P.; Norton, L.; Smart, S. (2016). Bee nectar plant diversity of Great Britain. NERC Environmental Information Data Centre. http://doi.org/10.5285/623a38dd-66e8-42e2-b49f-65a15d63beb5

References

1. Smith, P. et al. (2011). Regulating services. *In*: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment, UNEP-WCMC, Cambridge.

2. Smart, S., Dunbar, M.J., Emmett, B.A., Marks, S., Maskell, L.C., Norton, L.R., Rose, P., Simpson, I.C. (2010). An Integrated Assessment of Countryside Survey data to investigate Ecosystem Services in Great Britain. Technical Report No. 10/07 NERC/Centre for Ecology & Hydrology 230pp. (CEH Project Number: C03259).

3. Maskell, L. C. et al. (2013). Exploring the ecological constraints to multiple ecosystem service delivery and biodiversity. *J Appl Ecol.* **50** (3) 561-571.

4. Biesmeijer, J.C., Roberts, S.P.M., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., Schaffers, A.P., Potts, S.G., Kleukers, R., Thomas, C.D., Settele, J. & Kunin, W.E. (2006). Parallel declines in pollinators and insect -pollinated plants in Britain and the Netherlands. Science, 21, 351–354.

5. Williams, P.H. (1982). The distribution and decline of British Bumblebees (*Bombus Latr.*). *Journal of Apicultural Research* **21**, 236-245

6. Carvell, C., Roy, D.B., Smart, S.M., Pywell, R.F., Preston, C.D., Goulson, D. (2006). Declines in forage availability for bumblebees at a national scale. Biological Conservation, 132, 481–489.

7. Bunce et al. (2007). ITE land classification of Great Britain 2007 http://doi.org/10.5285/5f0605e4-aa2a-48ab-b47c-bf5510823e8f

8. Smart, S.M., Maskell, L.C., Norton, L.R., Scott, R., Carey, P.D., Murphy, J., Chamberlain, P.M., Wood, C.M., Bunce, R.G.H., Barr, C.J. (2008) Vegetation plots handbook. Technical Report No.2/07/NERC/Centre for Ecology and Hydrology 64pp, http://countrysidesurvey.org.uk/sites/default/files/pdfs/reports2007/CS_UK_2007_TR2.pdf

9. Jackson, D. (2000). Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. JNCC report 307

10. Maskell, L.C., Norton, L.R., Smart, S.M., Carey, P.D., Murphy, J., Chamberlain, P.M., Wood, C.M., Bunce, R.G.H., Barr, C.J. (2008). Field mapping Handbook. Technical Report No.1/07/NERC/Centre for Ecology and Hydrology 143pp http://countrysidesurvey.org.uk/sites/default/files/pdfs/reports2007/CS_UK_2007_TR1.pdf

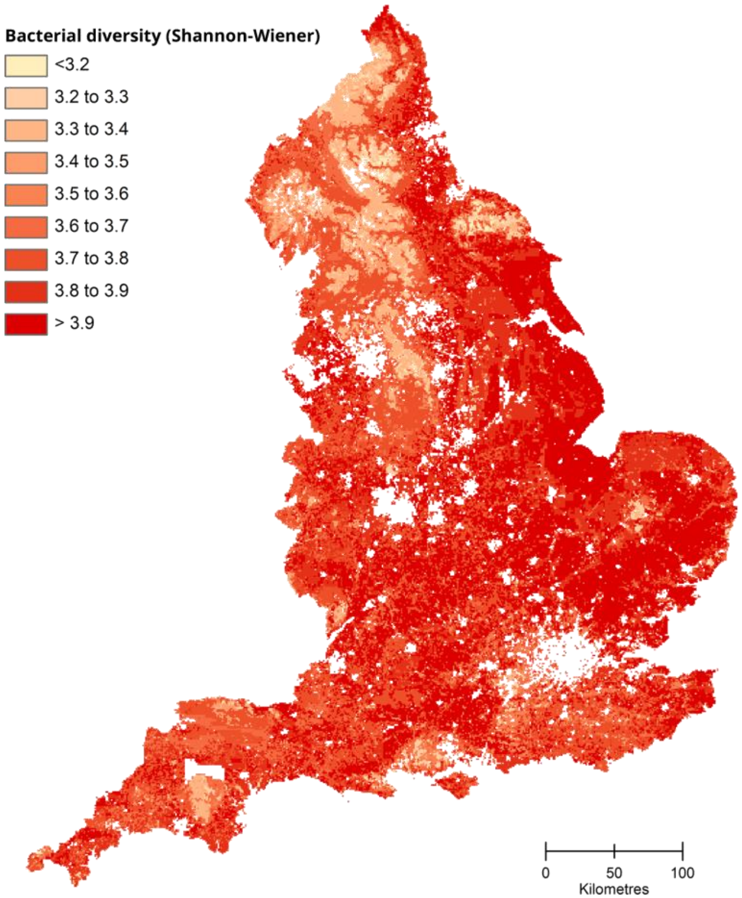
11. Stace, C. (1997). New Flora of the British Isles. Cambridge University press, Cambridge 2nd edition.

NATURAL ENGLAND

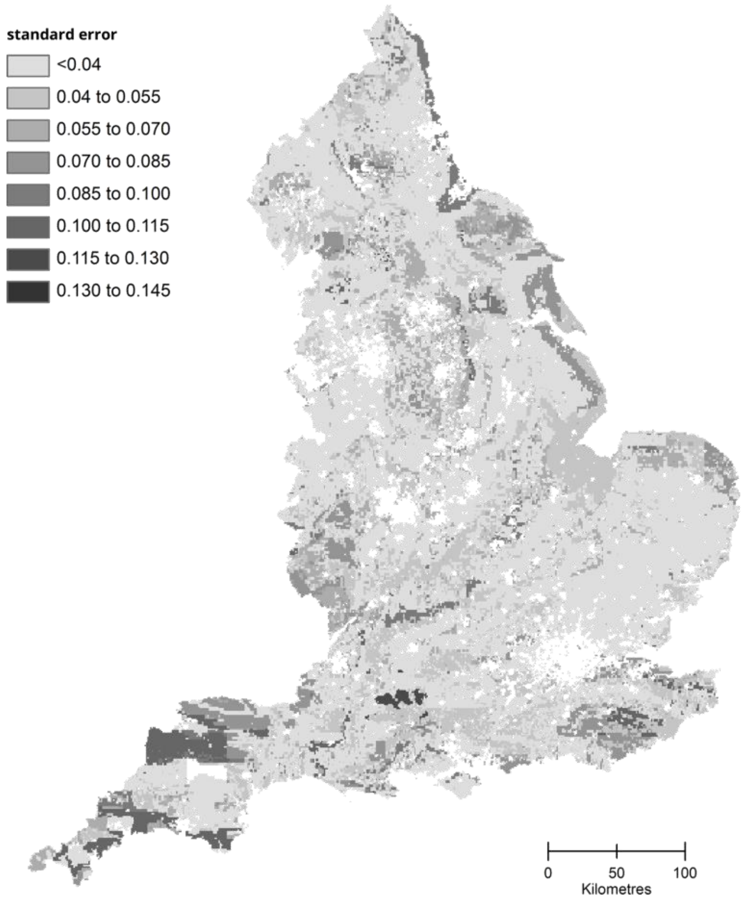
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Soil bacteria

Mean estimates of soil bacterial diversity in topsoil (0-15cm depth)



Uncertainty: Standard error from the mean estimates



Soil bacteria
Mean estimates of soil bacterial diversity in topsoil.

What does this map show?

Mean estimates of bacterial diversity in topsoil (0-15cm depth) measured using the Shannon diversity index [1], a mathematical measure of species diversity in a given community. Soil bacteria represent a major portion of the biodiversity in soils. As they are at the bottom of the soil food web, the bacterial communities play an important role in soil processes such as nutrient cycling, carbon sequestration and the cycling of greenhouse gases as well as in biodegrading pollutants.

The UK National Ecosystem Assessment (UKNEA 2011) recognises the importance of soil bacterial diversity as a component of natural capital for supporting ecosystem services, in particular nutrient cycling, soil formation and primary production. The supporting services underpin the delivery of provisioning and regulating ecosystem services; soil bacterial diversity particularly influences food, fibre and energy from agriculture and forestry, soil quality and climate regulation.

A number of factors can have a strong influence on soil bacterial diversity [2,3], for example, environmental variables such as soil chemistry (e.g. pH), climate and plant community structure. The map reflects these factors with differences in bacterial diversity shown between upland habitats subject to harsh climatic conditions with distinct plant communities and acidic soils, and lowland habitats, which tend to have less acidic soils, agriculturally associated flora and a milder climate.

Soil bacterial diversity has high spatial variability. The standard error map gives an indication of the uncertainty in the estimated values shown on the mean bacterial diversity; the greater the standard error the greater the uncertainty.

How was this map produced?

This map was produced by using measurements of bacterial diversity from soil in the Centre for Ecology & Hydrology Countryside Survey (2007), at 1280 sample locations across GB within 256 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on soil bacterial diversity values associated with a combination of habitat type and soil parent material: the geological material, bedrock, superficial and drift, from which soil develops.

What are the limitations of this map?

1. Areas such as urban and littoral rock are not sampled by Countryside Survey and therefore have no associated data. These areas are shown in white on the map.

2. In some circumstances sample sizes for particular habitat/parent material combinations were insufficient to estimate mean values. These areas are also shown in white on the map.

3. The map shows mean values at a 1 km square resolution. The standard error attributed to the mean estimates is only valid at 1km square resolution. The standard error at different resolutions is unknown.

4. The values for each 1 km square are generated from a statistical model of samples from approximately 256 1 km squares. Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. Top soil (0-15cm depth) cores were taken from 1280 Countryside Survey sample locations within 256 1km squares [4,5].

2. Bacterial communities were assessed using molecular DNA analysis [2]. The Shannon diversity index was calculated for each sample [4,5]. The Shannon diversity index is a mathematical measure of species diversity in a community which takes into account both species diversity and the relative abundance of different species.

3. Areas of each unique combination of broad habitat (as documented by JNCC [6]) and parent material were identified using data derived from the Land Cover Map 2007 [7] and Parent Material Model 2009 [8], respectively for each 1km square.

4. Values for the Shannon diversity index from Countryside Survey sampled locations were then combined with habitat/parent material data.

5. Using a statistical model (a generalized additive model [9]), a mean estimate of Shannon diversity for each unique combination of habitat and parent material, was extrapolated across the whole of England.

6. The statistical model was also used to produce an associated standard error map. High values reflect high variability and hence greater uncertainty in the mean estimates.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

Reuse of the data is subject to the terms of the Open Government Licence and you must cite:

> Henrys, P.A.; Keith, A.M.; Robinson, D.A.; Emmett, B.A. (2014). Model estimates of topsoil microbes [Countryside Survey]. NERC Environmental Information Data Centre. http://doi.org/10.5285/53210c27-87fc-46e4-a3d6-e731003dc541

References

1. Spellerberg, I.F; Fedor, P.J (2003) A tribute to Claude Shannon (1916–2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon–Wiener' Index. Global Ecology & Biogeography 12, 177-179

2. Griffiths, R.I.; Thomson, B.C.; James, P; Bell, T.; Bailey, M.; Whiteley, A.S. (2011) The bacterial biogeography of British soils. Environmental Microbiology, 13 (6). 1642-1654. http://doi.org/10.1111/j.1462-2920.2011.02480.x

3. de Vries, F. T., Manning, P., Tallowin, J. R. B., Mortimer, S. R., Pilgrim, E. S., Harrison, K. A., Hobbs, P. J., Quirk, H., Shipley, B., Cornelissen, J. H. C., Kattge, J., Bardgett, R. D. (2012) Abiotic drivers and plant traits explain landscape-scale patterns in soil microbial communities. Ecology Letters 15(11): 1230-9. http://doi.org/10.1111/j.1461-0248.2012.01844.x

4. Emmett, B.A., Frogbrook, Z.L., Chamberlain P.M., Griffiths R., Pickup R., Poskitt, J., Reynolds B., Rowe E., Rowland P., Spurgeon D., Wilson J., Wood, C.M. (2008). Countryside Survey Technical Report No.03/07: Soils Manual. Centre for Ecology & Hydrology.

5. Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C. (2010). CS Technical Report No. 9/07: Soils Report from 2007. Centre for Ecology & Hydrology.

6. Jackson, D.L. (2000) Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. JNCC Report 307, 73 pages, ISSN 0963 8091.

7. Morton, R.D.; Rowland, C.S.; Wood, C.M.; Meek, L.; Marston, C.G.; Smith, G.M. (2014). Land Cover Map 2007 (1km dominant target class, GB) v1.2. NERC Environmental Information Data Centre. http://doi.org/10.5285/6cffd348-dad7-46f9-9c5b-8d904dd5b2a2

8. British Geological Survey. Soil Parent Material Model. http://www.bgs.ac.uk/products/onshore/soilPMM.html [Accessed Jan 15th 2016]

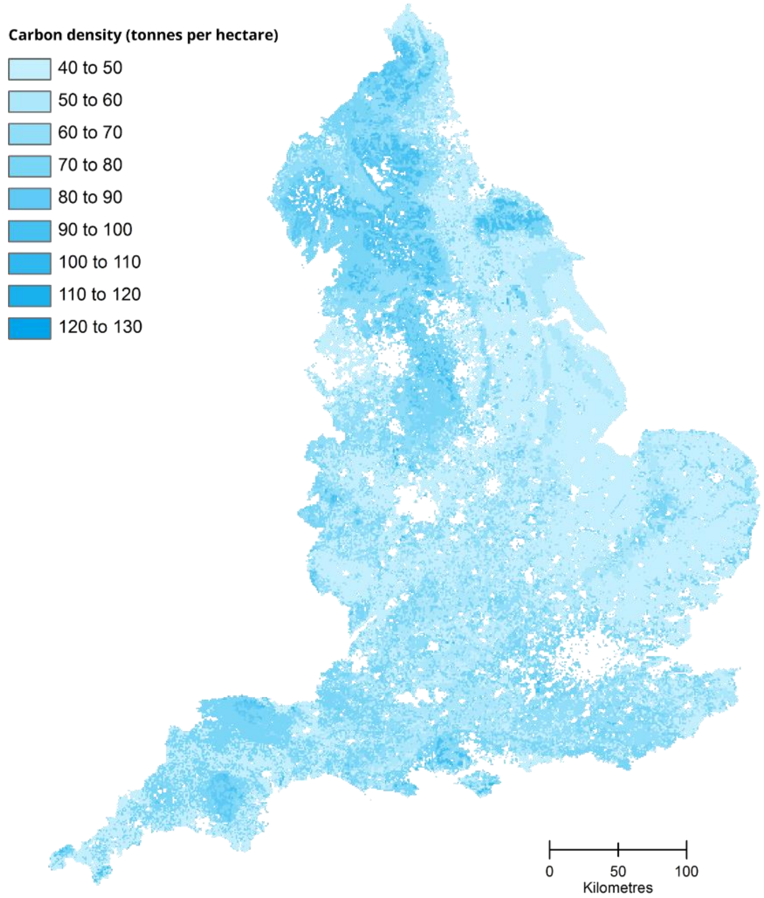
9. Hastie, T. J.; Tibshirani, R. J. (1990). Generalized Additive Models. Chapman & Hall/CRC.

NATURAL ENGLAND

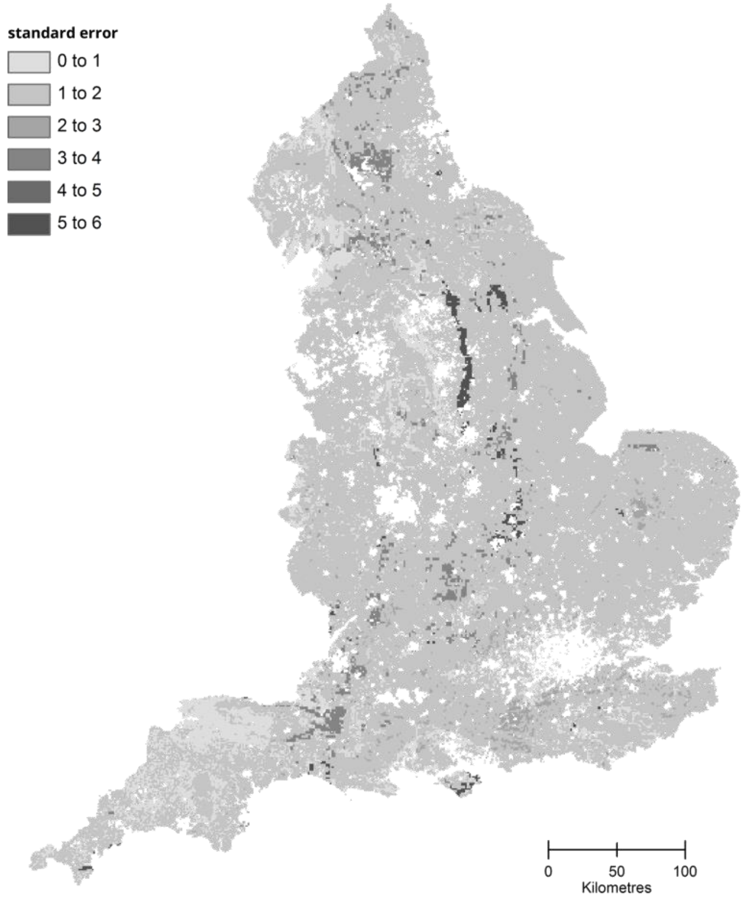
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Soil carbon

Mean estimates of carbon density in topsoil (0-15cm depth)



Uncertainty: Standard error from the mean estimates



Soil carbon

Mean estimates of carbon density in topsoil (tonnes per hectare).

What does this map show?

Mean estimates of topsoil (0-15cm depth) carbon density in tonnes per hectare. Soil organic carbon is essential to soil function due to its role as the primary energy source in soils and in maintaining soil structural condition, resilience and water retention. As soil carbon is the biosphere's largest carbon reservoir, soils play a vital role in climate regulation.

The UK National Ecosystem Assessment (UKNEA 2011) recognises soil carbon as a key component of natural capital for supporting ecosystem services, in particular soil formation, primary production and nutrient cycling, as well as the water cycle, through its effect on water storage in soil. The supporting services underpin the delivery of provisioning and regulating ecosystem services; soil carbon is particularly important for climate regulation and soil quality. The UKNEA found that it is well established that loss of carbon from soil, due to climate warming, with increased rates of organic matter decomposition and leaching, is a threat to soil formation.

Certain habitat types are associated with greater densities of soil carbon; these include acid grassland, coniferous woodland, bogs and heathland. Soil carbon is found at lower densities in arable habitats and improved grassland [1]. The map reflects this variation with greater carbon densities in upland peatland areas of England and lower densities in areas where arable crops or pastoral systems dominate. Soil carbon has high spatial variability. The standard error map gives an indication of the uncertainty in the estimated values shown on the mean carbon density map; the greater the standard error the greater the uncertainty.

How was this map produced?

This map was produced using measurements of carbon from soil collected in the Centre for Ecology & Hydrology Countryside Survey (2007) at 2614 sample locations across GB, within 591 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on carbon density values associated with a combination of habitat type and soil parent material: the geological material, bedrock, superficial and drift, from which soil develops.

What are the limitations of this map?

1. Areas such as urban and littoral rock are not sampled by Countryside Survey and therefore have no associated data. These areas are shown in white on the map.

2. In some circumstances sample sizes for particular habitat/parent material combinations were insufficient to estimate mean values. These areas are also shown in white on the map.

3. The map shows mean values at a 1 km square resolution. The standard error attributed to the mean estimates is only valid at 1km square resolution. The standard error at different resolutions is unknown.

4. The values for each 1 km square are generated from a statistical model of samples from approximately 591 1 km squares. Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. Top soil (0-15cm depth) cores were taken from 2614 Countryside Survey sample locations within 591 1km squares [1,2].

2. Carbon density was calculated for each core, by combining measurements of carbon concentration with bulk density (grams of soil per cm^3) [1,2].

3. Areas of each unique combination of broad habitat (as documented by JNCC [3]) and parent material, were identified using data derived from the Land Cover Map 2007 [4] and Parent Material Model 2009 [5], respectively for each 1km square.

4. Values for carbon density from Countryside Survey sampled locations were then combined with habitat/parent material data.

5. Using a statistical model (a generalized additive model [6]), a mean estimate of carbon density for each unique combination of habitat and parent material, was extrapolated across the whole of England.

6. The statistical model was also used to produce an associated standard error map. High values reflect high variability and hence greater uncertainty in the mean estimates.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

Reuse of the data is subject to the terms of the Open Government Licence and you must cite:

> Henrys, P.A.; Keith, A.M.; Robinson, D.A.; Emmett, B.A. (2012). Model estimates of topsoil carbon [Countryside Survey]. NERC Environmental Information Data Centre. http://doi.org/10.5285/9e4451f8-23d3-40dc-9302-73e30ad3dd76

References

1. Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C. (2010). CS Technical Report No. 9/07: Soils Report from 2007. Centre for Ecology & Hydrology.

2. Emmett, B.A., Frogbrook, Z.L., Chamberlain P.M., Griffiths R., Pickup R., Poskitt, J., Reynolds B., Rowe E., Rowland P., Spurgeon D., Wilson J., Wood, C.M. (2008). Countryside Survey Technical Report No.03/07: Soils Manual. Centre for Ecology & Hydrology.

3. Jackson, D. L. (2000) Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. JNCC Report 307, 73 pages, ISSN 0963 8091.

4. Morton, R.D.; Rowland, C.S.; Wood, C.M.; Meek, L.; Marston, C.G.; Smith, G.M. (2014). Land Cover Map 2007 (1km dominant target class, GB) v1.2. NERC Environmental Information Data Centre. http://doi.org/10.5285/6cffd348-dad7-46f9-9c5b-8d904dd5b2a2

5. British Geological Survey. Soil Parent Material Model. http://www.bgs.ac.uk/products/onshore/soilPMM.html [Accessed Jan 15th 2016]

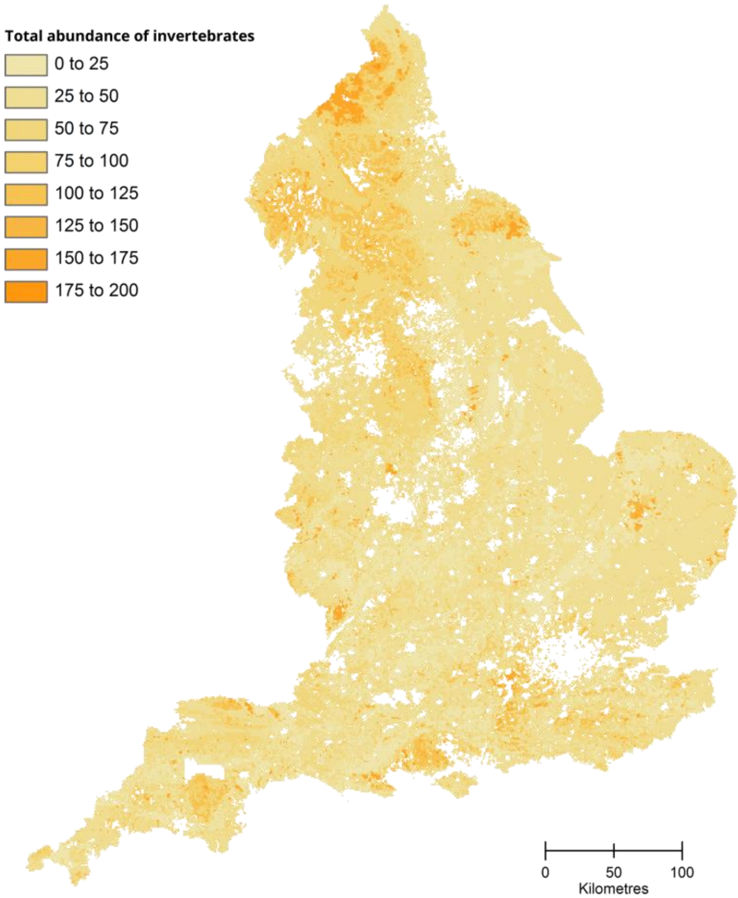
6. Hastie, T. J.; Tibshirani, R. J. (1990). Generalized Additive Models. Chapman & Hall/CRC.

NATURAL ENGLAND

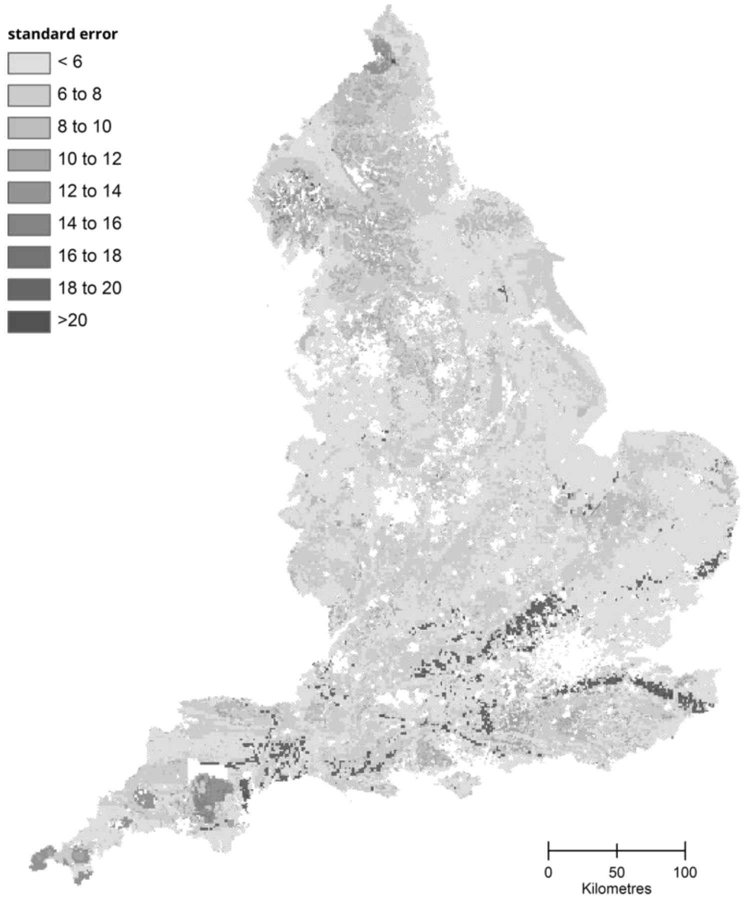
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Soil invertebrates

Mean estimates of total abundance of invertebrates in topsoil (0-8cm depth)



Uncertainty: Standard error from the mean estimates



Soil invertebrates
Mean estimates of total abundance of invertebrates in topsoil.

What does this map show?
Mean estimates of total abundance of invertebrates in topsoil (0-8cm depth). The activities of the soil biota are critical for the provision of many important soil functions including biomass production and storing, filtering and transforming nutrients. Because they are intimately involved in many important soil functions and are fundamental to maintaining soil quality, the biological components of soils have considerable potential as indicators of soil quality.

The UK National Ecosystem Assessment (UKNEA 2011) recognises the importance of soil invertebrates as a component of natural capital for supporting ecosystem services, in particular nutrient cycling, soil formation and primary production. The supporting services underpin the delivery of provisioning and regulating ecosystem services; soil invertebrate abundance is particularly important for soil quality, which is linked to almost all the other regulating services.

Soil invertebrates tend to be found in higher densities in semi-natural less intensively managed habitats such as woodland, acid grassland and dwarf shrub heath. Soil invertebrates are found at lower quantities in more intensively managed habitats such as arable, improved and neutral grassland [1]. The map shows higher densities in the north and west of England with lower densities in the South East. Small patches of higher density may be related to the presence of semi-natural habitats. The standard error map gives an indication of the uncertainty in the estimated values shown on the total abundance map; the greater the standard error the greater the uncertainty

How was this map produced?
This map was produced by using measurements of total number of invertebrates extracted from soil cores in the Centre for Ecology & Hydrology Countryside Survey (2007) at 927 sample locations across GB within 238 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on the total number of invertebrates extracted associated with a combination of habitat type and soil parent material: the geological material, bedrock, superficial and drift, from which soil develops.

What are the limitations of this map?
1. Areas such as urban and littoral rock are not sampled by Countryside Survey and therefore have no associated data. These areas are shown in white on the map.

2. In some circumstances sample sizes for particular habitat/parent material combinations were insufficient to estimate mean values. These areas are also shown in white on the map.

3. The map shows mean values at a 1 km square resolution. The standard error attributed to the mean estimates is only valid at 1km square resolution. The standard error at different resolutions is unknown.

4. The values for each 1 km square are generated from a statistical model of samples from approximately 238, 1 km squares. Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. Top soil (0-8cm depth) cores were taken from 927 Countryside Survey sample locations within 238 1km squares [1,2].

2. Soil invertebrates were extracted from cores using a dry Tullgren extraction method, which heats the surface of soil cores to extract the invertebrates. Once collected, soil invertebrates were identified to major taxa and counted [1,2].

3. Areas of each unique combination of broad habitat (as documented by JNCC [3]) and parent material were identified using data derived from the Land Cover Map 2007 [4] and Parent Material Model 2009 [5], respectively for each 1km square.

4. Values for total abundance of invertebrates from Countryside Survey sampled locations were then combined with habitat/parent material data.

5. Using a statistical model (a generalized additive model [6]), a mean estimate of total abundance of invertebrates for each unique combination of habitat and parent material, was extrapolated across the whole of England.

6. The statistical model was also used to produce an associated standard error map. High values reflect high variability and hence greater uncertainty in the mean estimates.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

Reuse of the data is subject to the terms of the Open Government Licence and you must cite:

> Henrys, P.A.; Keith, A.M.; Robinson, D.A.; Emmett, B.A. (2012). Model estimates of topsoil invertebrates [Countryside Survey]. NERC Environmental Information Data Centre. http://doi.org/10.5285/f19de821-a436-4b28-95f6-b7287ef0bf15

References

1. Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C. (2010). CS Technical Report No. 9/07: Soils Report from 2007. Centre for Ecology & Hydrology.

2. Emmett, B.A., Frogbrook, Z.L., Chamberlain P.M., Griffiths R., Pickup R., Poskitt, J., Reynolds B., Rowe E., Rowland P., Spurgeon D., Wilson J., Wood, C.M. (2008). Countryside Survey Technical Report No.03/07: Soils Manual. Centre for Ecology & Hydrology.

3. Jackson, D. L. (2000) Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. JNCC Report 307, 73 pages, ISSN 0963 8091.

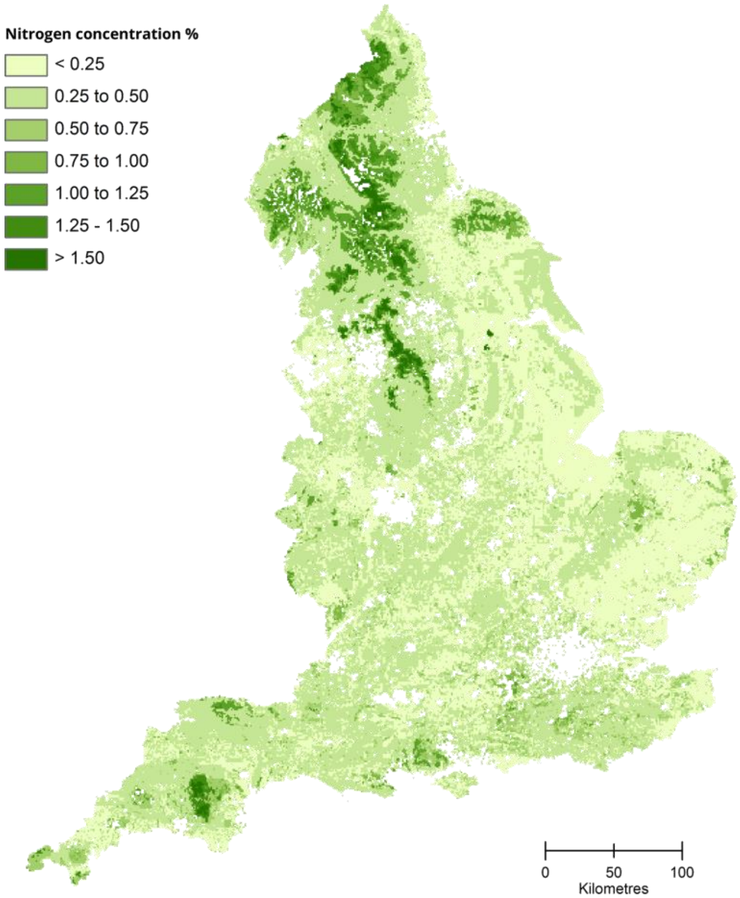
4. Morton, R.D.; Rowland, C.S.; Wood, C.M.; Meek, L.; Marston, C.G.; Smith, G.M. (2014). Land Cover Map 2007 (1km dominant target class, GB) v1.2. NERC Environmental Information Data Centre. http://doi.org/10.5285/6cffd348-dad7-46f9-9c5b-8d904dd5b2a2

5. British Geological Survey. Soil Parent Material Model. http://www.bgs.ac.uk/products/onshore/soilPMM.html [Accessed Jan 15th 2016]

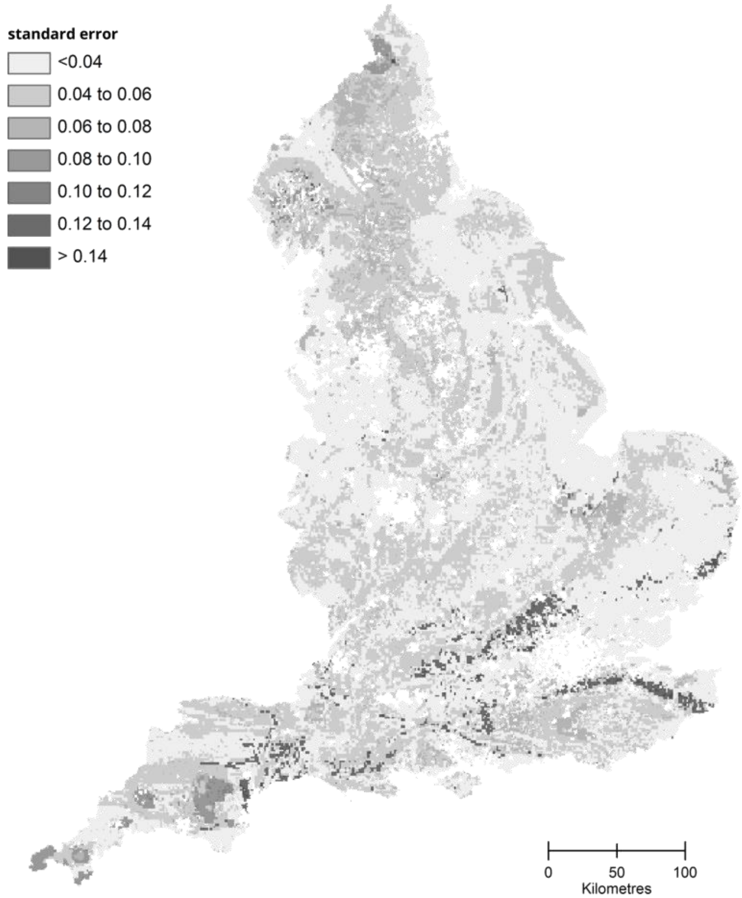
6. Hastie, T. J.; Tibshirani, R. J. (1990). Generalized Additive Models. Chapman & Hall/CRC.

Soil nitrogen

Mean estimates of total nitrogen concentration in topsoil (0-15cm depth)



Uncertainty: Standard error from the mean estimates



Soil nitrogen

Mean estimates of total nitrogen concentration in topsoil (%).

What does this map show?

Mean estimates of total nitrogen concentration in topsoil (0-15cm depth) in percent dry weight of soil. Soil total nitrogen concentration is a basic measurement of soil fertility and along with soil organic carbon, plays a key role in soil formation processes.

The UK National Ecosystem Assessment (UKNEA 2011) recognises soil nitrogen as a key component of natural capital for supporting ecosystem services, in particular nutrient cycling, as well as soil formation and primary production. The supporting services underpin the delivery of provisioning and regulating ecosystem services; soil nitrogen particularly influences food, fibre and energy from agriculture and forestry, water quality and soil quality. The UK NEA notes that nitrogen enrichment from fertilisers and atmospheric deposition has resulted in substantial changes in plant productivity, plant species diversity and composition and an accelerated rate of nitrogen cycling.

This map shows that the greatest concentrations of total nitrogen in topsoil may be found in upland areas, rather than in lowland improved agricultural areas as might be expected. This is potentially due to the large amounts of nitrogen locked up in organic matter in these areas. Nitrogen held in organic matter within peat soils, such as these, is not generally considered to be readily available for plant growth.

The map reflects that the greatest soil total nitrogen concentrations were found in acid grassland, dwarf shrub heath and bog habitats in England [1]. The lowest concentrations were in arable land and Improved grassland [1].Factors that could influence soil nitrogen concentration include the use of nitrogen fertilisers, atmospheric nitrogen deposition and the interaction between the vegetation and the soil in cycling of nutrients to respond to changes in nitrogen availability. Soil total nitrogen is relatively insensitive to short-term changes, but over a longer time period gives an overall indication of trends in soil fertility and changes in nutrient status in relation to other parameters such as carbon.

Soil nitrogen has high spatial variability. The standard error map gives an indication of the uncertainty in the estimated values shown on the mean total nitrogen map; the greater the standard error the greater the uncertainty.

How was this map produced?

This map was produced by using measurements of nitrogen concentration from soil collected in the Centre for Ecology & Hydrology Countryside Survey (2007), at 1024 sample locations across GB within 256 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on total nitrogen concentration values associated with a combination of habitat type and soil parent material: the geological material, bedrock, superficial and drift, from which soil develops.

What are the limitations of this map?

1. Areas such as urban and littoral rock are not sampled by Countryside Survey and therefore have no associated data. These areas are shown in white on the map.

2. In some circumstances sample sizes for particular habitat/parent material combinations were insufficient to estimate mean values. These areas are also shown in white on the map.

3. The map shows mean values at a 1 km square resolution. The standard error attributed to the mean estimates is only valid at 1km square resolution. The standard error at different resolutions is unknown.

4. The values for each 1 km square are generated from a statistical model of samples from approximately 256 1 km squares. Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. Top soil (0-15cm depth) cores were taken from 1024 Countryside Survey sample locations within 256 1km squares [1,2].

2. Total nitrogen concentration was calculated for each soil core. [1,2].

3. Areas of each unique combination of broad habitat (as documented by JNCC [3]) and parent material were identified using data derived from the Land Cover Map 2007 [4] and Parent Material Model 2009 [5], respectively for each 1km square.

4. Values for total nitrogen concentration from Countryside Survey sampled locations were then combined with habitat/parent material data.

5. Using a statistical model (a generalized additive model [6]), a mean estimate of total nitrogen concentration for each unique combination of habitat and parent material, was extrapolated across the whole of England.

6. The statistical model was also used to produce an associated standard error map. High values reflect high variability and hence greater uncertainty in the mean estimates.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

Reuse of the data is subject to the terms of the Open Government Licence and you must cite:

> Henrys, P.A.; Keith, A.M.; Robinson, D.A.; Emmett, B.A. (2012). Model estimates of topsoil nutrients [Countryside Survey]. NERC Environmental Information Data Centre. http://doi.org/10.5285/7055965b-7fe5-442b-902d-63193cbe001c

References

1. Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C. (2010). CS Technical Report No. 9/07: Soils Report from 2007. Centre for Ecology & Hydrology.

2. Emmett, B.A., Frogbrook, Z.L., Chamberlain P.M., Griffiths R., Pickup R., Poskitt, J., Reynolds B., Rowe E., Rowland P., Spurgeon D., Wilson J., Wood, C.M. (2008). Countryside Survey Technical Report No.03/07: Soils Manual. Centre for Ecology & Hydrology.

3. Jackson, D. L. (2000) Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. JNCC Report 307, 73 pages, ISSN 0963 8091.

4. Morton, R.D.; Rowland, C.S.; Wood, C.M.; Meek, L.; Marston, C.G.; Smith, G.M. (2014). Land Cover Map 2007 (1km dominant target class, GB) v1.2. NERC Environmental Information Data Centre. http://doi.org/10.5285/6cffd348-dad7-46f9-9c5b-8d904dd5b2a2

5. British Geological Survey. Soil Parent Material Model. http://www.bgs.ac.uk/products/onshore/soilPMM.html [Accessed Jan 15th 2016]

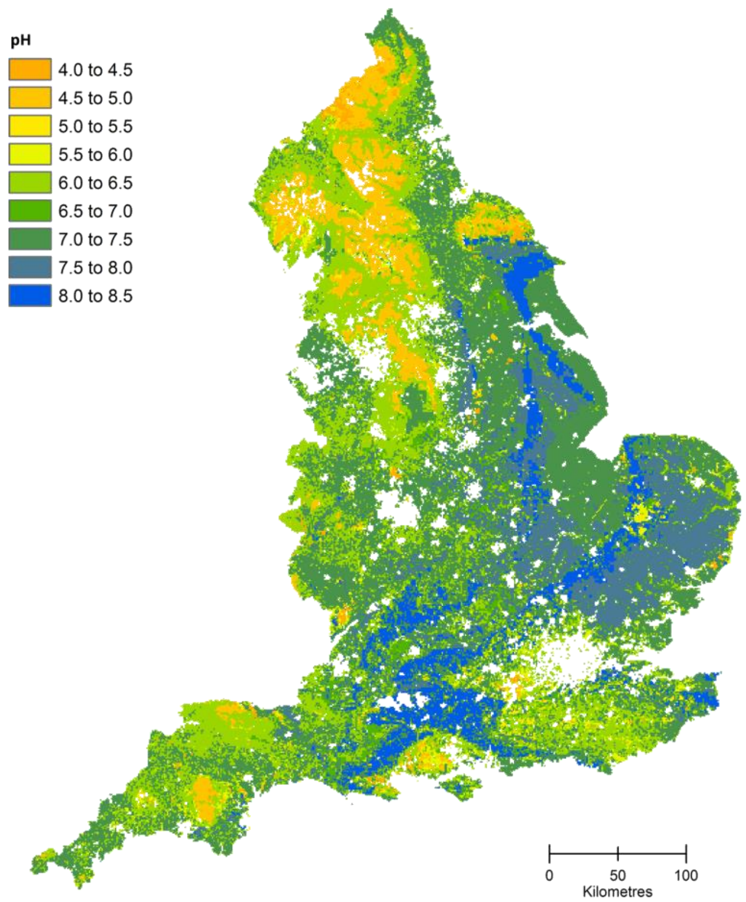
6. Hastie, T. J.; Tibshirani, R. J. (1990).Generalized Additive Models. Chapman & Hall/CRC.

NATURAL ENGLAND

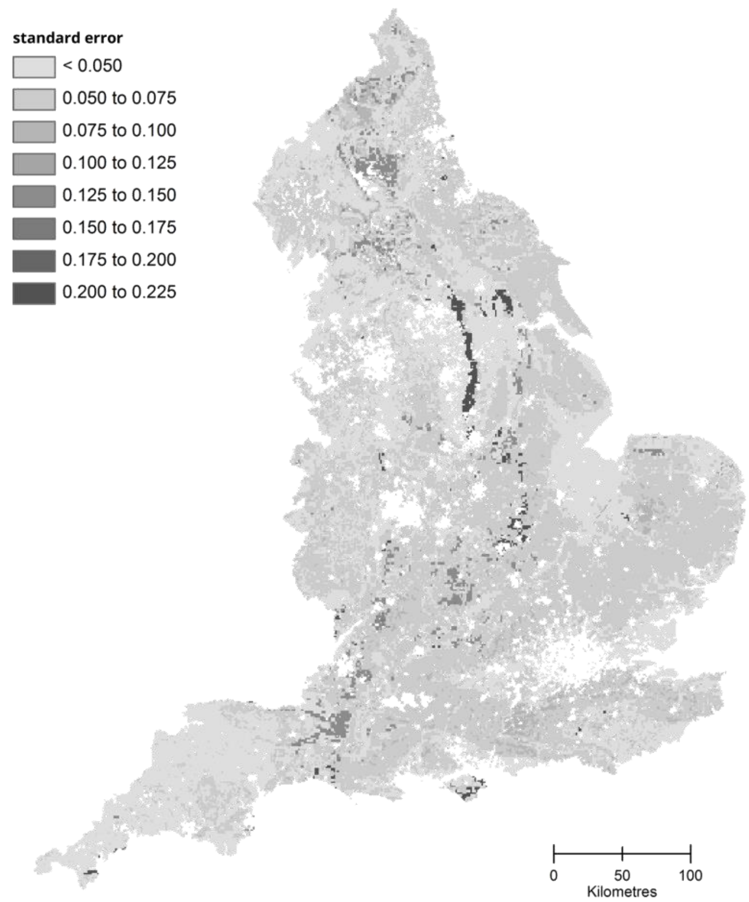
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Soil pH

Mean estimates of topsoil pH (0-15cm depth)



Uncertainty: Standard error from the mean estimates



Soil pH
Mean estimates of topsoil pH.

What does this map show?
Mean estimates of pH in topsoil (0-15cm depth). Measures of pH give an indication of soil acidity. Soil pH also affects the concentrations of trace elements in soils; in general most trace elements become more available to plants and microbes in neutral or slightly acidic soils.

The UK National Ecosystem Assessment (UKNEA 2011) recognises soil pH as a key component of natural capital for supporting ecosystem services, in particular nutrient cycling, as well as soil formation and primary production. The supporting services underpin the delivery of provisioning and regulating ecosystem services; soil pH is particularly important for food, fibre and energy from agriculture and forestry, soil quality and water quality. The UKNEA notes, that it is well established that there has been a recent decrease in soil acidity due to declines in sulphate deposition and "acid rain" since the late 1970’s.

Soils beneath enclosed farmland broad habitats (including arable habitats, improved and semi-improved neutral grassland) are the least acid in England with pH generally >6. More acidic soils (pH<5) are associated with upland habitats such as acid grassland, bog and heathland [1]. The map reflects these differences showing, for instance, soils with higher pH in East Anglia and lower pH in upland areas in the North West.

Soil pH has high spatial variability. The standard error map gives an indication of the uncertainty in the estimated values shown on the mean pH map; the greater the standard error the greater the uncertainty.

How was this map produced?
This map was produced by using measurements of pH from soil in the Centre for Ecology & Hydrology Countryside Survey (2007), at 2614 sample locations, across GB within 591 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on pH values associated with a combination of habitat type and soil parent material: the geological material, bedrock, superficial and drift, from which soil develops.

What are the limitations of this map?
1. Areas such as urban and littoral rock are not sampled by Countryside Survey and therefore have no associated data. These areas are shown in white on the map.

2. In some circumstances sample sizes for particular habitat/parent material combinations were insufficient to estimate mean values. These areas are also shown in white on the map.

3. The map shows mean values at a 1 km square resolution. The standard error attributed to the mean estimates is only valid at 1km square resolution. The standard error at different resolutions is unknown.

4. The values for each 1 km square are generated from a statistical model of samples from approximately 591 1 km squares. Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. Top soil (0-15cm depth) cores were taken from 2614 Countryside Survey sample locations within 591 1km squares [1,2].

2. Topsoil pH was measured for each core [1,2].

3. Areas of each unique combination of broad habitat (as documented by JNCC [3]) and parent material were identified using data derived from the Land Cover Map 2007 [4] and Parent Material Model 2009 [5], respectively for each 1km square.

4. Values for soil pH from Countryside Survey sampled locations were then combined with habitat/parent material data.

5. Using a statistical model (a generalized additive model [6]), a mean estimate of soil pH for each unique combination of habitat and parent material, was extrapolated across the whole of England.

6. The statistical model was also used to produce an associated standard error map. High values reflect high variability and hence greater uncertainty in the mean estimates.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

Reuse of the data is subject to the terms of the Open Government Licence and you must cite:

> Henrys, P.A.; Keith, A.M.; Robinson, D.A.; Emmett, B.A. (2012). Model estimates of topsoil pH and bulk density [Countryside Survey]. NERC Environmental Information Data Centre. http://doi.org/10.5285/5dd624a9-55c9-4cc0-b366-d335991073c7

References

1. Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C. (2010). CS Technical Report No. 9/07: Soils Report from 2007. Centre for Ecology & Hydrology.

2. Emmett, B.A., Frogbrook, Z.L., Chamberlain P.M., Griffiths R., Pickup R., Poskitt, J., Reynolds B., Rowe E., Rowland P., Spurgeon D., Wilson J., Wood, C.M. (2008). Countryside Survey Technical Report No.03/07: Soils Manual. Centre for Ecology & Hydrology.

3. Jackson, D. L. (2000) Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. JNCC Report 307, 73 pages, ISSN 0963 8091.

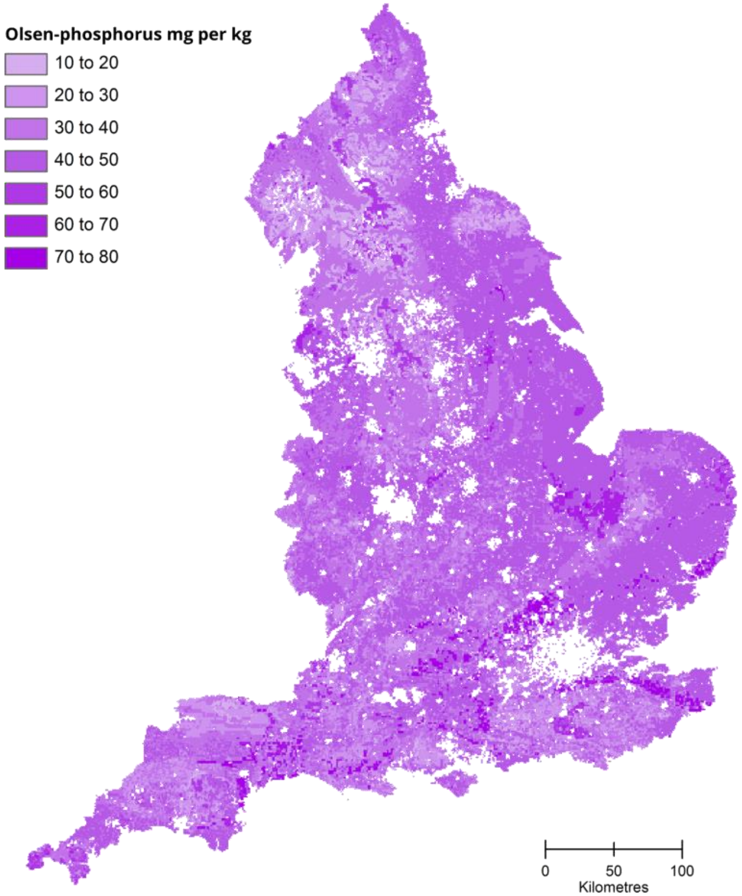
4. Morton, R.D.; Rowland, C.S.; Wood, C.M.; Meek, L.; Marston, C.G.; Smith, G.M. (2014). Land Cover Map 2007 (1km dominant target class, GB) v1.2. NERC Environmental Information Data Centre. http://doi.org/10.5285/6cffd348-dad7-46f9-9c5b-8d904dd5b2a2

5. British Geological Survey. Soil Parent Material Model. http://www.bgs.ac.uk/products/onshore/soilPMM.html [Accessed Jan 15th 2016]

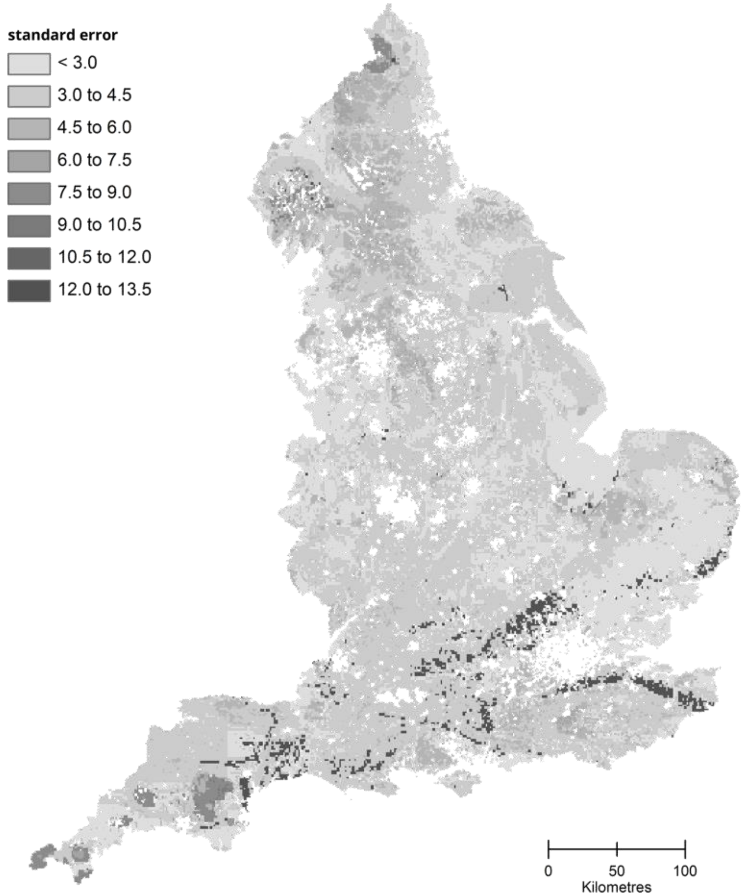
6. Hastie, T. J.; Tibshirani, R. J. (1990). Generalized Additive Models. Chapman & Hall/CRC.

Soil phosphorus

Mean estimates of phosphorus in topsoil (0-15cm depth)



Uncertainty: Standard error from the mean estimates



Soil phosphorus
Mean estimates of phosphorus concentration in topsoil.

What does this map show?

Mean estimates of Olsen-phosphorus concentration in topsoil (0-15cm depth) in milligrams per kg dry soil. This was calculated using the Olsen-phosphorus method, which is a measure of the amount of soil phosphorus available to plants.

The UK National Ecosystem Assessment (UKNEA 2011) recognises phosphorus in soil as a key component of natural capital for supporting ecosystem services, in particular nutrient cycling, as well as soil formation and primary production. The supporting services underpin the delivery of provisioning and regulating ecosystem services; soil phosphorus particularly influences food, fibre and energy from agriculture and forestry, soil quality and water quality.

Soil phosphorus provides an index of fertility of agricultural soils, phosphorus concentration varies across habitat type but is greatest in soil from arable habitats and improved grassland [1]. It would be expected that areas of managed agricultural land in southern and eastern England would have greater phosphorus concentrations and could be distinguished from semi-natural areas in the north and west. In habitats such as grasslands, high soil phosphorus concentrations can constrain the restoration of plant species diversity.

Soil phosphorus has high spatial variability. The standard error map gives an indication of the uncertainty in the estimated values shown on the mean phosphorus concentration map; the greater the standard error the greater the uncertainty.

How was this map produced?

This map was produced by using measurements of Olsen-phosphorus from soil collected in the Centre for Ecology & Hydrology Countryside Survey (2007), at 1054 sample locations across GB, within 256 1km squares. Measurements were extrapolated up to a national level using statistical analysis. This extrapolation was based on phosphorus concentration values associated with a combination of habitat type and soil parent material: the geological material, bedrock, superficial and drift, from which soil develops.

What are the limitations of this map?

1. Areas such as urban and littoral rock are not sampled by Countryside Survey and therefore have no associated data. These areas are shown in white on the map.

2. In some circumstances sample sizes for particular habitat/parent material combinations were insufficient to estimate mean values. These areas are also shown in white on the map.

3. The map shows mean values at a 1 km square resolution. The standard error attributed to the mean estimates is only valid at 1km square resolution. The standard error at different resolutions is unknown.

4. The values for each 1 km square are generated from a statistical model of samples from approximately 256 1 km squares. Hence the map does not show direct measurements at all locations.

Further detail on the steps for creating this map

1. Top soil (0-15cm depth) cores were taken from 1054 Countryside Survey sample locations within 256 1km squares [1,2].

2. Olsen-phosphorus concentration was calculated for each core to measure the amount of soil phosphorus available to plants. [1,2].

3. Areas of each unique combination of broad habitat (as documented by JNCC [3]) and parent material were identified using data derived from the Land Cover Map 2007 [4] and Parent Material Model 2009 [5], respectively for each 1km square.

4. Values for Olsen-phosphorus concentration from Countryside Survey sampled locations were then combined with habitat/parent material data.

5. Using a statistical model (a generalized additive model [6]), a mean estimate of phosphorus concentration for each unique combination of habitat and parent material, was extrapolated across the whole of England.

6. The statistical model was also used to produce an associated standard error map. High values reflect high variability and hence greater uncertainty in the mean estimates.

How to obtain the data

Data can be downloaded from https://eip.ceh.ac.uk/naturalengland-ncmaps.

Reuse of the data is subject to the terms of the Open Government Licence and you must cite:

> Henrys, P.A.; Keith, A.M.; Robinson, D.A.; Emmett, B.A. (2012). Model estimates of topsoil nutrients [Countryside Survey]. NERC Environmental Information Data Centre. http://doi.org/10.5285/7055965b-7fe5-442b-902d-63193cbe001c

References

1. Emmett, B.A., Reynolds, B., Chamberlain, P.M., Rowe, E., Spurgeon, D., Brittain, S.A., Frogbrook, Z., Hughes, S., Lawlor, A.J., Poskitt, J., Potter, E., Robinson, D.A., Scott, A., Wood, C., Woods, C. (2010). CS Technical Report No. 9/07: Soils Report from 2007. Centre for Ecology & Hydrology.

2. Emmett, B.A., Frogbrook, Z.L., Chamberlain P.M., Griffiths R., Pickup R., Poskitt, J., Reynolds B., Rowe E., Rowland P., Spurgeon D., Wilson J., Wood, C.M. (2008). Countryside Survey Technical Report No.03/07: Soils Manual. Centre for Ecology & Hydrology.

3. Jackson, D. L. (2000) Guidance on the interpretation of the Biodiversity Broad Habitat Classification (terrestrial and freshwater types): Definitions and the relationship with other classifications. JNCC Report 307, 73 pages, ISSN 0963 8091.

4. Morton, R.D.; Rowland, C.S.; Wood, C.M.; Meek, L.; Marston, C.G.; Smith, G.M. (2014). Land Cover Map 2007 (1km dominant target class, GB) v1.2. NERC Environmental Information Data Centre. http://doi.org/10.5285/6cffd348-dad7-46f9-9c5b-8d904dd5b2a2

5. British Geological Survey. Soil Parent Material Model. http://www.bgs.ac.uk/products/onshore/soilPMM.html [Accessed Jan 15th 2016]

6. Hastie, T. J.; Tibshirani, R. J. (1990).Generalized Additive Models. Chapman & Hall/CRC.

NATURAL ENGLAND

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL