User Guide:

Spatial Prioritisation of Land Management for Carbon Dataset 2023

August 2025

Natural England Commissioned Report NECR510

www.gov.uk/natural-england

NATURAL ENGLAND

About Natural England

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Introduction

Natural England (NE) is the Government's statutory adviser for the natural environment. They play a vital role in delivering the Government's Environment Act and corresponding Environment Improvement Plan, addressing the twin challenges of biodiversity loss and climate change means Natural England's work is more important now than ever. This user guide outlines the methodologies used to create national maps of terrestrial carbon storage, sequestration and abatement opportunities across England. It describes the methods undertaken to create the maps and suggests how they can be best used. It is accompanied by the GIS layers, a technical report and a set of FME workbenches.

Plate 1: Young oak leaves sequestering carbon and releasing oxygen to the atmosphere *Photos © Environment Systems*

The maps represent a strategic resource for England, that indicate the range of carbon storage and sequestration values in tonnes per hectare (t C ha^{-1} yr) & (, at a local scale (e.g., 1:50,000). They are presented as a series of raster datasets for use in GIS systems at a resolution of $25m^2$. These maps will assist users to find out where the most important carbon stores in soil and vegetation are in their areas, and where sequestration of carbon is currently high. The abatement map can be used to find potential opportunity areas to enhance carbon sequestration and storage. For Natural England they will assist with strategic analysis for the three schemes that will underpin the Environment Act and the Environment Improvement Plan:

- Sustainable Farming Incentive (SFI).
- Local Nature Recovery (LNR).
- Landscape Recovery (LR).

In addition, it is intended that the work can be used to prioritise sites for action when considering:

- Nature based management solution delivery.
- Meeting the Government targets for tree planting to assist carbon storage and sequestration.
- Peat restoration work.
- Management of other protected sites.

These new data will contribute to Natural England's vision of 'thriving nature for people and planet', by allowing policy makers and land managers to understand the terrestrial carbon resource. It will help protect and enhance existing carbon stores whilst also demonstrating opportunities to enhance carbon sequestration through changes in land use and management.

Background

Carbon (in the form of carbon dioxide (CO_2) is removed from the atmosphere by plants through the process of photosynthesis, this is then stored in the stems or trunks and leaves above ground, and in the root system below ground (

Plate ***1***). When leaves fall on the soil and roots die, soil microbial communities consume the material releasing a certain amount of CO_2 with the residual becoming bound to the soil particles and stored as soil carbon. The amount of carbon that can be locked away depends on the soil type and the past vegetation as well as the current land use (Gregg *et.al.* 2021). Where deep brown earth soils have been under native woodland species for many thousands of years, very deep reserves of soil carbon can be found. Similarly in peatland systems, where it is too wet and acid and there is, therefore little oxygen available in the system, most soil microbial species cannot exist, and the vegetation does not fully decay but forms a carbon rich peat environment. All these processes keep carbon ‘locked’ away from the atmosphere. When land management actions disturb the soil, oxygen is added to the system, this allows more soil microbes to utilise the stored carbon, turning it back into CO_2 through respiration, which can then enter the atmosphere. In peatlands, if the surface dries out, oxygen enters the system and allows microbial activity to begin and CO_2 to be released.

Plate 2: Native woodland is an excellent carbon store Photos © Environment Systems

There are, therefore, two key features which are important in considering how our environment helps mitigate climate change. The first is ensuring that carbon stored in soil, particularly peat soils that have a very large carbon reservoir, remain intact and that carbon locked up in woody vegetation is also kept locked up. The first two layers were created using the amount of carbon stored in the soil and vegetation, modelled across the landscape. In areas where these resources are high any plans for changes in land management should be carefully considered to minimise disturbance and retain as much stored carbon as possible.

The second way that our environment can help mitigate climate changes is by locking up CO_2 from the atmosphere into vegetation, particularly woody vegetation (Plate 2), this process is called sequestration, and this is the third layer mapped. Finally, areas where carbon is being lost and change in land management could result in a more favourable state of the soil /vegetation system which would allow more carbon to be sequester or reduce carbon loss from long term carbon stores, is mapped as a carbon abatement layer.

This work has built upon the previous carbon storage and sequestration mapping carried out for Natural England in 2014. This study suggested approximate values of carbon stored and sequestration rates in vegetation and soils. In the modelling carried out for all four layers. these values were taken and turned into spatially relevant figures.

The maps are issued under an Open Government Licence (OGL) to maximise impact and shareability. To achieve this the project only selected input layers that are open data. This means that there are some datasets that are more spatially accurate. To mitigate this, some of the OGL data was amalgamated.

The resulting maps are designed to allow Natural England, policy makers and other stakeholders to identify:

1. High carbon habitats and land parcels where it is important to protect existing carbon stocks and improve management that supports continued retention of carbon in soils and vegetation.
2. Sites and land parcels where a change in land management or land use would promote carbon sequestration / abatement and storage in soils / vegetation or reduce net carbon loss.
3. Maximise sequestration potential through integrating higher carbon ecosystem restoration to appropriate areas.

The maps produced are designed for strategic national and regional scale analysis.

How to Use the Maps - Accuracy and Fitness for Purpose

These maps are intended to be used for strategic purposes to identify and prioritise possible areas to protect or investigate further. This work guides the user to areas where such schemes and work may give greater value.

Because carbon values vary within fields, due to soil, the soil water regime, slope, habitat and management, the only way to get accurate carbon values for fields (for example for an offsetting scheme) is to take a soil sample. These maps are not intended to replace this system.

Plate 3: Carbon can be caried deep into the soil profiles by the actions of roots
Photos © Environment Systems

The values are derived, in part, from the use of habitats maps, which in some cases are not up to date and which have known limitations to accuracy, for example:

- The priority habitat Inventory (PHI) does contain older survey data

- The National Forest Inventory (NFI) was completed in 2016 from remote survey, much felling and replanting has occurred in the last 6-7 years.
- Living England has been modelled from satellite imagery and quotes an accuracy of 88%). The classes are broad but make a good starting point for understanding habitats. More information can be found about Living England[1] from the website Living England: From Satellite Imagery to a National Scale Habitat Map.
- Coastal Floodplain and grazing marsh PHI, is not a single habitat type and therefore is not accurate in its prediction of habitat and vegetation carbon content.

The soil data have been modelled based on Cranfield's strategic soil data set Soilscapes[2] which is designed to be used at a land scape (1:250,000) scale.

Carbon Storage Layers

Carbon (in the form of CO_2) is removed from the atmosphere by plants through the process of photosynthesis, then stored in the stems or trunks and leaves above ground and in the root system below ground. This helps ‘lock’ carbon away from the atmosphere, therefore mitigating climate change.

Soil Carbon storage

Over time in mineral soils, the carbon in the roots is broken down by soil fauna and flora. Soil organic matter comprises of the soil microbes and the decaying plant. Some soils hold more organic matter than others as the organic carbon components can bind to the mineral particles in the soil, allowing the carbon to be retained in the soil. As part of this Carbon Cycle[3] this builds up over time until an equilibrium is reached between the amount of organic material input into the system and that that is able to be incorporated and held in the system. With deep rooted tree, herbs and grass carbon can be carried deep into the soil profile (Plate 3).

The amount of carbon stored within a mineral soil depends upon the soil type, with clay rich and silt rich soils storing more carbon than sandy soils. This process can be influenced by a number of different factors including rainfall and temperature, slope aspect, habitat and land management. If the land use remains stable the soil carbon stored will remain stable. Positive changes in management to enhance carbon include the use of farmyard manure rather than an inorganic fertiliser. Negative management practices, such as ploughing, allows oxygen to enter the system which can lead to carbon being released from the soil into the atmosphere as carbon dioxide.

[1]NERR141 Edition 1 Living England 2022-23 Technical User Guide https://publications.naturalengland.org.uk/publication/5260859937652736

[2] Available from http://www.landis.org.uk/soilscapes/

[3] https://en.wikipedia.org/wiki/Carbon_cycle

Enhancing the carbon content of mineral soil has other benefits as well as helping mitigate climate change. It gives a better soil structure which is more resistant to compaction from heavy machinery and poaching from animals. It also helps the soil retain more water in a form that allows a slow release, providing increased resilience to drought.

Plate 4: A bare peat face which could erode losing carbon following drainage
Photos © Environment Systems

Within peat soils, carbon storage operates by a different process. In a non-compromised or fully functional state peat soils are fully saturated with water for most of the year, either from excess rainfall or from excess ground water. This leads to the minimal decomposition of plant biomass, so soil carbon builds up faster than decomposition can occur, so no equilibrium is reached, to form a very carbon-rich layer of peat. This layer in blanket bogs, fens and raised bogs can become several metres thick over long periods of time as sequestration continues indefinitely, therefore making peatland soils a key carbon storage resource. However, if the peats are damaged so leading to drying out the soil microbial activity can re-start, and as the carbon is utilised by the soil microfauna, carbon dioxide and methane are then released to the atmosphere, changing a carbon sink that is sequestering carbon, into a source of greenhouse gas emissions.

Land use on peatland soils plays a very important role. Where peatlands have been drained, either for grazing or for afforestation, they will constantly release CO_2 to the atmosphere (UK Peatland Strategy 2018) (Plate 4). Climate change is also accelerating this impact on peatlands, with most now being drier than they have been the past 600 years. (Swindles *et. al.,* 2019). It is therefore very important that peat soils in the UK are urgently conserved and restored in order to retain them as sinks of carbon.

Why is understanding Soil carbon storage important?

As well as soil being an excellent natural carbon sink, locking carbon away from the atmosphere and reducing the amount of greenhouse gasses produced soil carbon has a number of other excellent benefits. The more carbon in minerals soils, the better the soil functions, it is generally better aerated, giving more change for nutrient cycling. Organic carbon enhances the water holding capacity of the soil and reduces the chance that machinery will compact the soil.

Summary of mapping approach

The datasets used for this model were:

- Habitat data conflated from Living England, PHI, NFI, Ancient Woodland
- Soil data conflated from Soilscapes and the NE Peatland Map
- Slope - >18°
- Protected areas: SSSI's, SAC's, LNR's and NNR's

Mineral and organic soils: Soilscapes was used as the base data for the mineral and organic soils. For areas where habitats are likely to be stable and indicative of good ecological condition a modification was used to indicate the likely increase in the score of soil carbon. The modifiers used were:

- the habitat overlying the soil (the more natural / semi-natural the higher the score)
- Indications that the habitats might be in good ecological condition, the PHI and the Ancient Woodland datasets were used as a proxy, to describe this.
- Slope, habitats occurring on slopes over 18° are likely to have thinner soils and therefore likely to store less carbon.

Peat soils: The Natural England Peat Map (Natural England 2008) was used to describe the shallow and deep peat soils. Modifiers were again used to assess the impact of the habitats and wider environment on the likely storage of carbon in the peat. there included:

- the habitat overlying the soil (bog and fen habitats had a high score. Arable land was awarded a much-reduced score as carbon is lost from peat soils under arable management.)
- Indications that the habitats might be in good ecological condition, the PHI and the was used as a proxy, to describe this.
- Slope, habitats occurring on steep slopes have in general a thinner soil, as erosion processes tend to move soil material downhill. A value of over 18° was used to show as a proxy for thinner soils. These soils are likely to store less carbon and are more prone to erosion (Dawson and Smith, 2007).

Soil depth is an important consideration when evaluating how much carbon is likely to be stored within the soil. Most carbon is held in the topsoil, although a lesser amount of carbon can be held deep into the soil profiles. In order to build this consideration into the model each soil type was allocated to one of four depth classes:

- Shallow soils with a profile likely to be 15-50 cm or less. The models assumed a 30 cm depth for carbon calculations.
- Normal depth mineral soils with a profile between 1 m and 1.25 m. The models assumed a 1 m depth for carbon calculations.
- Blanket peat soils. The models assumed a 2 m depth for carbon calculations.
- Raised bog and fen peat soils. The models assumed a 4 m depth for carbon calculations.

Plate 5: Peatland in poor condition, eroding Photos © Environment Systems

The values reported here may be higher than other studies which consider the topsoil carbon only. This is the part of the soil store that can be most easily modified. They generally report carbon of the top 30 cm. The resulting map can be seen in Figure .

Using the soil carbon mapped layer

This layer is helpful in giving a strategic idea of where high carbon stores are likely to be found within your area. It Is very Important that we maintain these stores as much as possible. For example;

- if new development is proposed and a soil rich in carbon is likely to be affected then provision should be made from the beginning for a soil management plan to preserve as much of the soil resource as possible;
- when change in agricultural land management is likely, consideration should be given to alternatives such as a no-plough system or a system that actively incorporates organic matter back into the soil;
- where peatland is in poor condition (that is it is bare or has hags and drains, Plate 5) every effort should be made to restore the vegetation cover and re-wet the surface. Eroding bog emits carbon, whilst intact bog can slowly sequester carbon and do so continually.

For more precise spatial planning / management we recommend using a detailed up-to-date local scale (e.g.,1:10,000) habitat map and a more detailed soil map (e.g., NatMap Vector by Cranfield University) and adding as much management and condition data as possible. To be considered for carbon credits, field-based soil sampling will be needed.

Classes

Mineral soils hold less carbon than peaty soils or deep peat. This map has been coloured up to differentiate between the different types of soils:

- Mineral soils are displayed from light green (low carbon) to dark green (moderate carbon),
- peaty soils from light orange (moderate carbon) to dark orange (high carbon),
- deep peats which can often contain more than two or three meters of organic material are displayed in a gradient of browns (high carbon).

An approximate amount of carbon stored (t ha^{-1}) in a 25 m by 25 m area is obtainable using the data layer in a GIS and the 'identify feature' tool.

Accompanying data

This user guide is accompanied by a full technical report and a set of spreadsheets explaining the logic and showing how the different attributes were scored for their value to carbon when input into the model. This analysis was carried out using an FME workbench which is held by Natural England. The GIS data are accompanied by a style file which you can implement to see the data in the colours and classes presented for these maps. These colours have been chosen to emphasise the difference in carbon values rather than reflecting a mathematical scale. They are available for ESRI's Arcmap and ArcPro as .lyr files, and QGIS as .sld files.

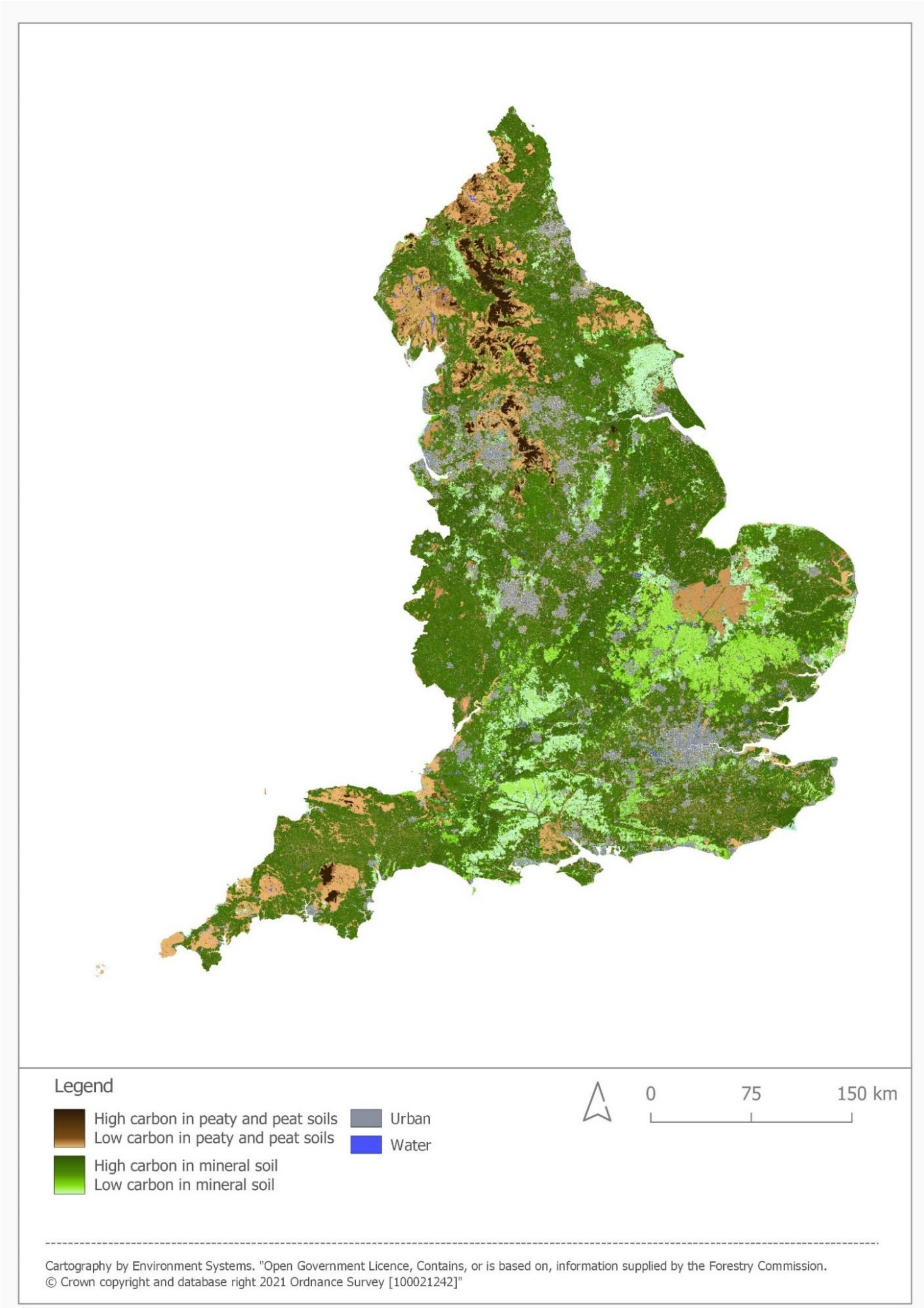

Figure 1: Soil Carbon Storage

Vegetation carbon storage

Vegetation stores carbon as it grows, taking it in the form of CO_2 and using the carbon to grow, stems, trunks, roots and leaves and respiring the oxygen back to the atmosphere. Globally, vegetation may hold about 450 billion tonnes of carbon (Erb *et. al.*, 2018). Whilst Milne and Brown (1995) estimate Great Britain held 114 M tonnes of carbon in its vegetation. Many natural habitats such as ancient woodlands, heathlands and wetlands sequester more carbon than they use annually, as do perennial crops such as long-term grass leys. This is a very important stock of stored carbon, locking up the resource and preventing its release back into the atmosphere. The vegetation dies back in the winter, with leaf-fall generally incorporated into the below ground carbon resource, although the microorganisms that eat them will respire a certain amount of CO_2 back to the atmosphere as the carbon cycle continues.

Plate 6: Ancient oak trees store carbon for centuries Photos © Environment Systems

Land cover that is managed for crops or pasture stores very little above ground carbon, as the above ground elements of the vegetation are harvested and the carbon used as energy in food; this includes most arable cropping and pasture, which is cut for silage or hay. Forage eaten by the animals enters a different food chain which has its own emissions profile.

Trees are particularly important (Plate 6), however if they are grown as an energy crop, they have a temporary storage effect until they are felled. Even if used for energy though, the carbon has been recycled from the air into the trees so it is regarded as renewable energy.

When grown for the building industry or furniture, or other similar type products which retain the wood, then the carbon will be locked away for the lifetime of the object. In general, the woodier the plant material the more carbon stored above ground. Most wood and other plant biomass is composed of roughly of 50 % carbon by weight, the precise amount varies depending on species, age, management, and growing condition.

These data layer show the probable distribution of carbon stored in the vegetation across the UK.

Summary of Mapping Approach

Three data component layers were collated together to form a continuous habitat data layer for England using the best, freely available information on habitat types. these were:

- The National Forest Inventory (2016).
- The single layer priority habitat dataset (various dated).
- Living England habitat map from satellite imagery (2020).

From the collation, each habitat type was scored in terms of the likely carbon they would store above ground. These data were taken form a very wide range of scientific studies. Where slopes are very steep (greater than 18^o) then the habitat classes which are identified by their tree species were score slightly lower, this is because they tend to have thinner soils and support less growth of the tree above the ground. Where woodland is actively managed to retain trees a slight enhancing of scoring was given, with locations taken from ancient woodland data and the protected site data including SSSI, SAV, LNR and NNR.

Using the vegetation carbon storage layer

This layer is shown in Figure 2. The darker colours show where more carbon is likely to be stored. In areas with a high soil carbon, land managers should be mindful of making decisions which can maintain and enhance theses stores. For example;

- avoid felling trees, especially semi-natural and ancient woodland. Ensure that new developments and land management change includes trees and consider replanting with native species which have a longer-term storage of vegetation carbon and a greater benefit to biodiversity than non-native species.

- Avoid situations and take preventative action for habitats that are susceptible to fire, maintain the soil wetness of wetlands and avoid fires around woodlands in hot dry conditions.
- When replanting woodland consider continuous cover forestry (CCF) where small groups of trees are selectively harvested to maintain the correct conditions for soil carbon stores to be retained.
- Direct planting of trees into a woodland generally results in faster growth and therefore uptake and storge of CO_2 than letting an area rewild naturally. However, a broader range of tree species can be selected giving a number of different growth rates and so carbon extending uptake over a longer period of time and providing additional land management and ecological benefits.

For more precise spatial planning / management we recommend using a detailed up-to-date soil and habitat map and adding as much management and condition data as possible.

In order to be considered for carbon credits soil sampling will be needed (UK Woodland Carbon Code 2021)

Map Classes

This map is to highlight the differences between very little carbon stored above ground to areas with a larger store of above ground carbon, such as ancient woodland. Arable and temporary grass layers have very little or no above ground carbon, whilst permanent pastures have a small amount.

The GIS data are accompanied by a style file which you can implement to see the data in the colours and classes presented for these maps which have been chosen to emphasise the difference in land use rather than a mathematical scale. They are available for ESRI's Arcmap and ArcPro as .lyr files, and QGIS as .sld files.

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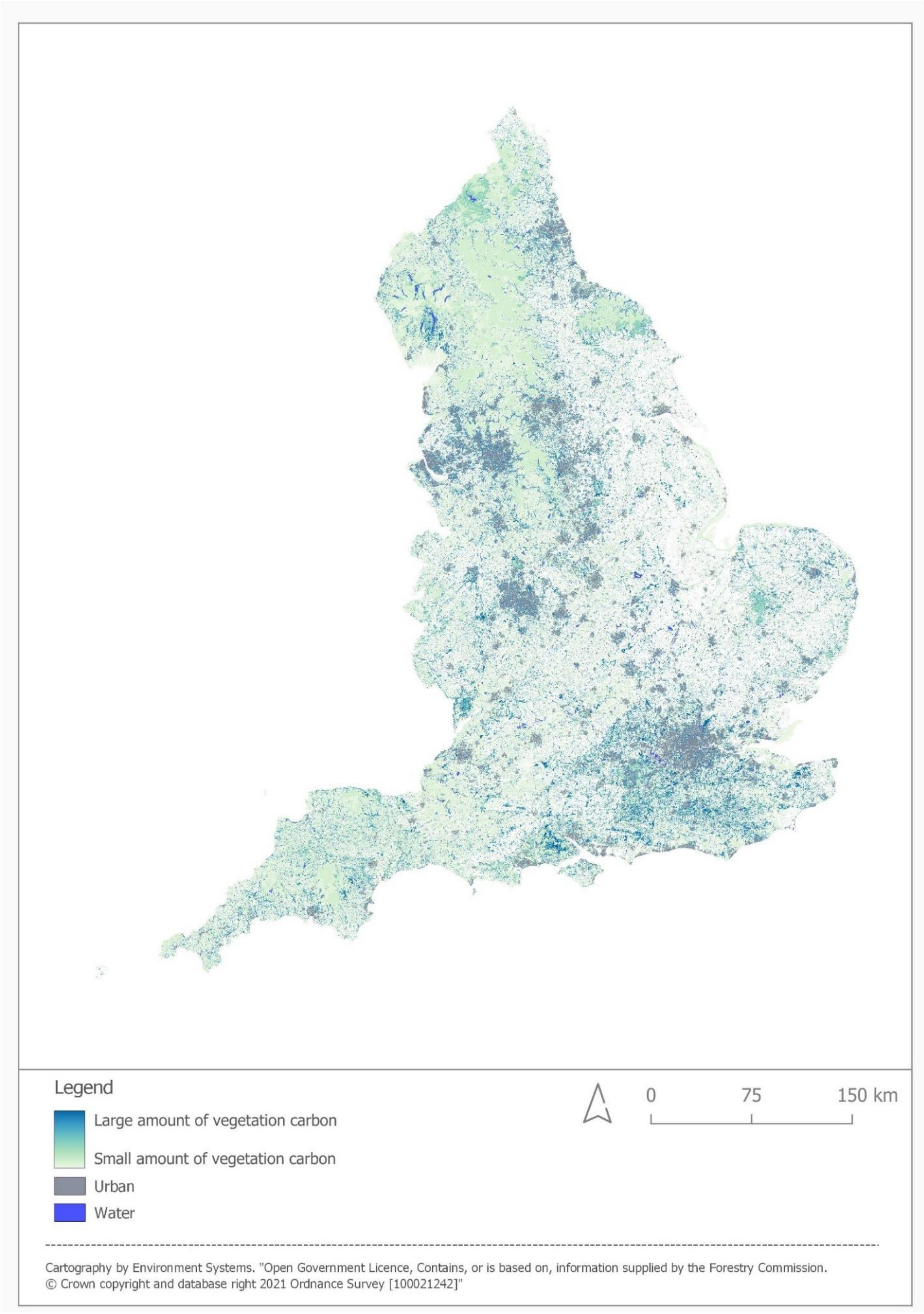

Figure 2: Carbon stored in vegetation

Total Carbon storage

The two layers presented above can be combined into a total carbon storage layer Figure 3. This shows the total amount of carbon the land is storing at present.

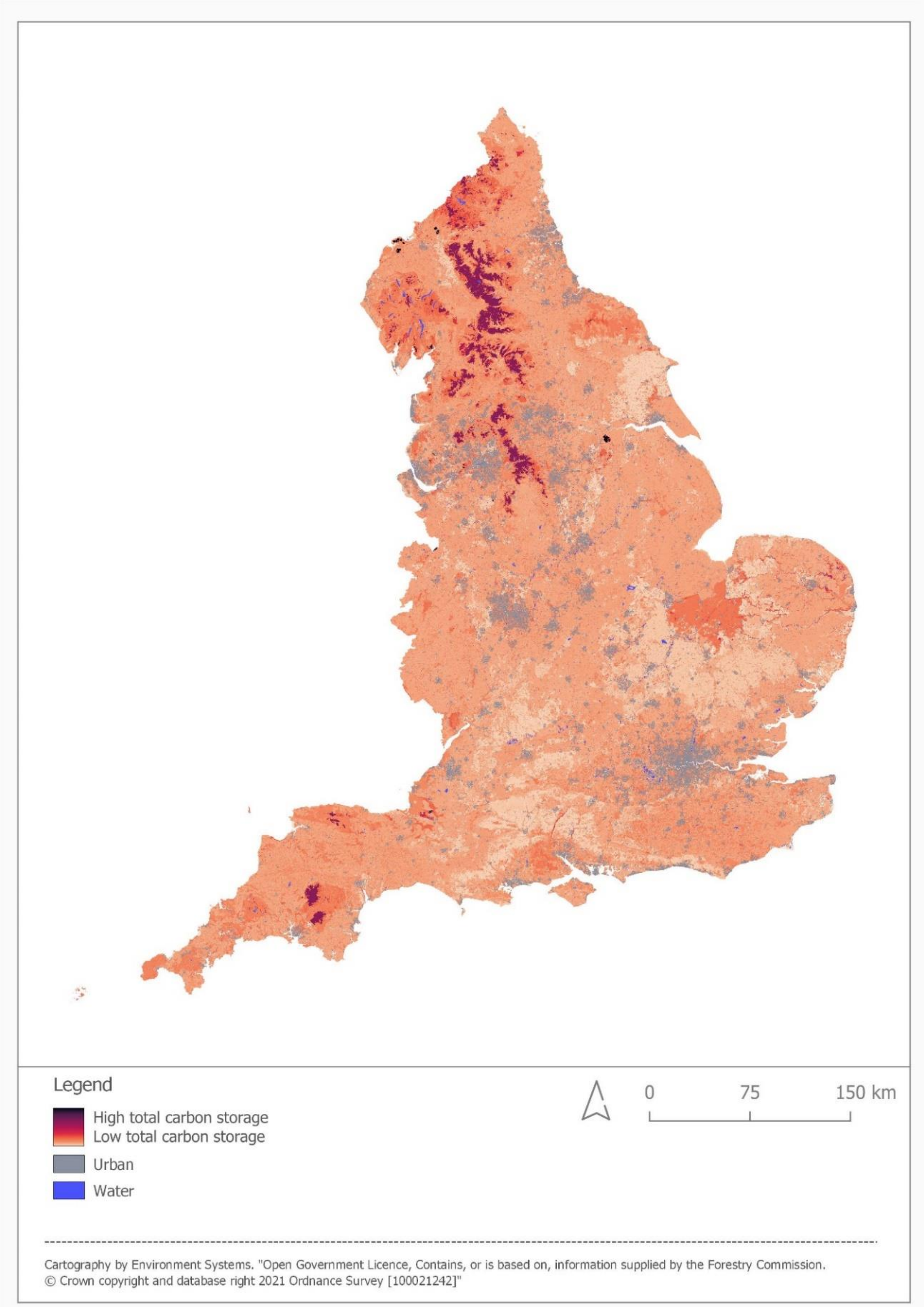

Figure 3: Total carbon stored in soil and vegetation

Carbon Sequestration

Carbon sequestration maps shows where the environment is actively capturing carbon dioxide and binding it in plants and soils (Plate 7). Unlike the carbon storage maps which shows what is stored from the past and where there is the largest risk to the environment of releasing carbon from storage; sequestration is what is being captured now with the current land use, habitats, agricultural grassland and crops, on an annual basis. It Is measured as tonnes of carbon dioxide equivalent per hectare pear year (t CO2e ha-1 y-1).

Plate 7: Young trees sequester large amounts of carbon as they grow Photos © Environment Systems

Most areas in agricultural production will have a neutral carbon balance where land management is sufficient to replace carbon lost in cropping or grazing from the vegetation and tillage from the soil. However, some soil types are very vulnerable to losing carbon when actively managed, these includes the very fertile but deep peats in the fens. Graves and Morris (2013) suggest that between 10 mm and 21 mm of peat soil is oxidised and lost every year in the fens.

The figures for habitat sequestration of carbon are taken from the 2019 Natural England Report NERR094 (Gregg *et.al.* 2021). This report identified some key gaps. As this is a prime research field at present some of those gaps have been filled with an analysis of scientific and grey literature these results can be found in the accompanying report. Each habitat type was assigned a likely score for sequestration using this information. Understanding carbon sequestration is less researched than understanding soil carbon storage and therefore the confidence in this dataset lower than in the carbon storage dataset

In this layer we have followed the IPCC methodology for reporting sequestration and loss[4] . Emissions are recorded as a positive value as they are adding to the carbon burden in the atmosphere. Sequestration is recorded as a negative value as it is removing carbon from the atmosphere.

Summary of mapping approach

Each of the habitats was assigned a likely sequestration value. Because management makes so much different to sequestration, we used the protected site data to indicate where land may be better managed, and this was given a slight uplift to the scores. This included:

- For woodland sites on very steep slopes a slight reduction was given as woodland on very steep slopes do not sequester as much carbon due to the more difficult growing conditions. here mineral soils had native vegetation designated by the PHI, the sequestration values were slightly uplifted as sequestration is likely to be at the highest level for that habitat type.
- The soil type is extremely important to sequestration with peatland soils losing carbon under arable and intensive grasslands at an extremely fast rate. The peatland maps were combined with the vegetation maps to highlight these areas.

Management of soil in intensive pastoral and arable systems has a profound effect on soil carbon values. It is easy to lose carbon repeatedly from a system due to ploughing. This is because as the plough turns the soil over carbon which has been buried is exposed the air this allows soil microbes to consume them, and they respired CO_2 back into the atmosphere. This is normally mitigated by applying organic soil ameliorants.

[4] https://unfccc.int/topics/land-use/workstreams/land-use--land-use-change-and-forestry-lulucf/reporting-of-the-lulucf-sector-by-parties-included-in-annex-i-to-the-convention

Many land managers are aware of the many benefits of having a good soil carbon resource and healthy soil and replace any lost carbon following reseeding. For this report we have therefore assumed that these productive systems have a neutral carbon sequestration result. This is an oversimplification, and for more detailed studies information about the types of management regimes and more detailed soil information would be needed to understand if these areas are a carbon source or sink.

Plate 8: Leaving a vegetation cover in winter to protect the soils Photos © Environment Systems

Using this layer

This layer is helpful in giving a strategic overview of where high sequestration values are to be found. It will also show where there is lower sequestration or carbon loss. Sequestration can always be enhanced either through active land management for example moving to a low tillage system, or leaving a vegetation cover intact over winter (Plate 8). Alternatively changing small areas of land use to a system with a higher sequestration potential can also be very beneficial. For example, planting, permanent headlands, hedges or shelterbelts on arable land, or planting native woodlands on areas of low output grasslands.

When considering a change of land use, it is essential that a field visit be caried out. In this study we have used the Natural England living England[5] class 'acid, neutral and calcareous grasslands' to indicate low input grazing systems where a change to woodland would be an appropriate option. Here the soil nutrient regime is more likely to be appropriate for the development of native woodland flora and a natural biodiverse ecosystem will be more likely to be easily established. However, where these grasslands are semi-natural in character and are of priority habitat quality, they should remain in grassland management as it is not appropriate for biodiversity to replace one priority habitat with another. A field visit will be necessary to make this decision.

If planning to plant native woodland on arable or intensive grassland, the phosphorus and nitrogen levels are likely to be much higher than would support the ground flora. For those with arable and productive grassland areas wishing to enter into carbon-based land use options and energy crops/ SRC who do not want to consider soil amelioration techniques such as stripping of topsoil (which do have a carbon loss burden, as carbon is oxidised form soil moved), consideration could be given to plantation of productive, fast growing hardwoods (including native species for timber) and softwoods where the fertile growing regime should provide a benefit to growth and capturing more carbon (providing weeds are suppressed).

This layer could be repeated every few years and used for monitoring how land management changes under new DEFRA initiates are providing enhanced carbon sequestration rates.

Please note, for site specific details such as spatial planning and individual management plans, we recommend running this analysis with spatially appropriate data collected at the field parcel scale and detailed soil information. To be eligible to receive carbon credits for a scheme, carbon sample will be needed from the soil and growth measurements from the vegetation.

Classes

Positive values for sequestration show where the land is actually losing carbon because of land management practices. These are coloured in the orange scale.

Figure shows most of these intensively managed lands are on the deep peat of the fens.

Colour ramps chosen with care as loss of carbon from peat under arable is an order of magnitude bigger than annual net sequestration from woodlands and other high carbon sequestration habitats.

Accompanying data

This user guide is accompanied by a full technical report and a set of spreadsheets showing the scorings given and explaining the logic. This analysis was carried out

[5] https://naturalengland.blog.gov.uk/2022/04/05/living-england-from-satellite-imagery-to-a-national-scale-habitat-map/

using an FME workbench which is held by Natural England.

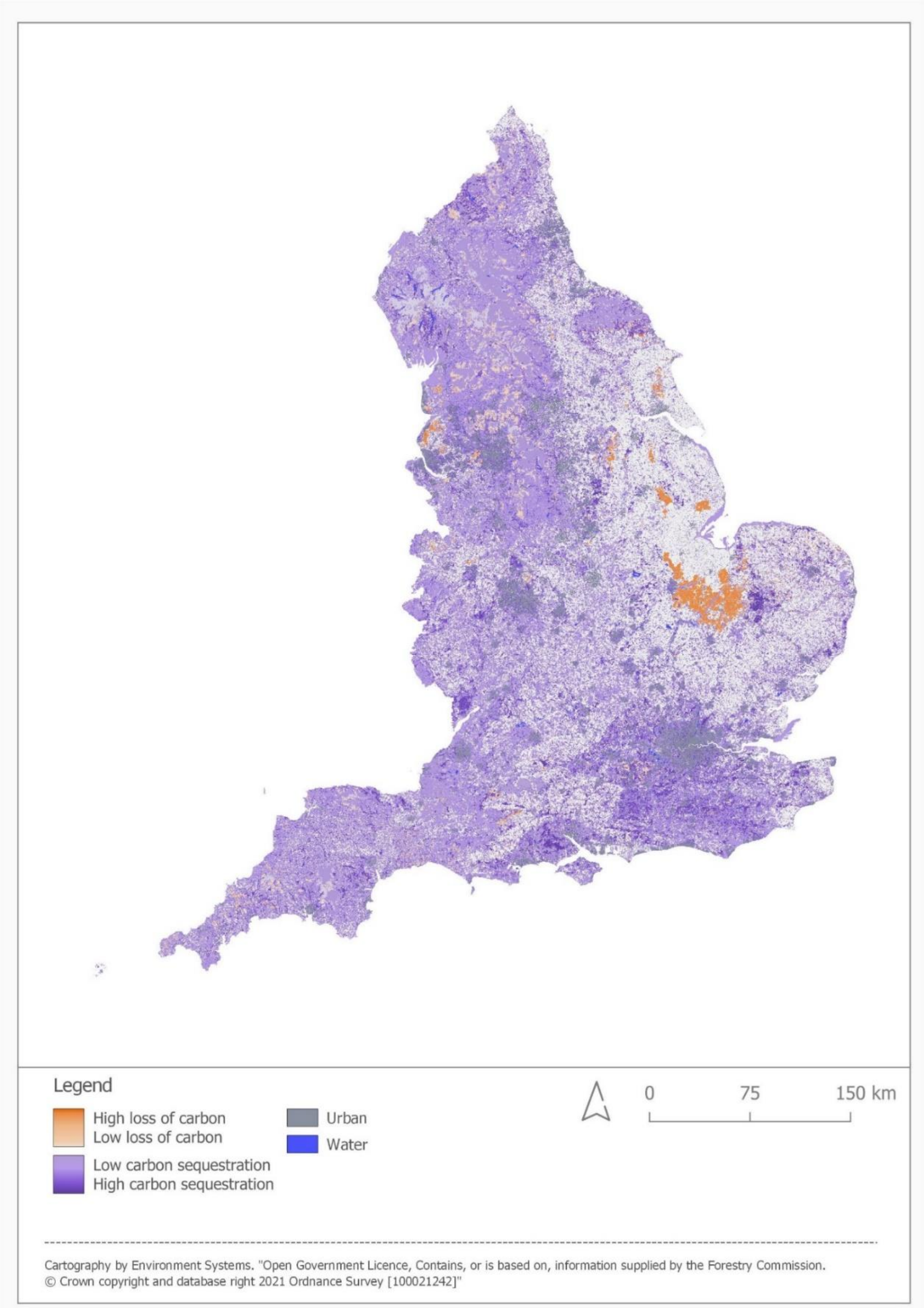

Figure 4: Carbon sequestration and carbon loss

Carbon Abatement

Rational

Carbon abatement is the reduction in carbon dioxide presently being released to the atmosphere from the environment when land use and management are in conflict with the best carbon outcome. This layer (Figure 5) compliments the carbon sequestration map (

Figure) and shows where different types of actions can be taken to maximise carbon storage and sequestration. Although it is technically possible with enough funding and engineering work to turn any habitat into any other; in many cases this is not desirable. The approach here has been to highlight the worst areas of the country for carbon loss and abatement potential. Where existing high quality semi natural habitat already exists there is likely to be opportunities to enhance carbon, but much of this is fine scale management decisions that a national data set cannot determine. So, a more precautionary approach has been applied that if a habitat presently exists on a site, land-use change has not been recommended. There will be many instances where an existing habitat could be Improved or changed to another habitat that would be more beneficial for carbon. Many habitats have become degraded through management practices over time, such as drainage, which means It now sits in a lower carbon state or is losing carbon through becoming dryer over time and as such has abatement potential such as conversion from a dry grassland habitat with drainage to much wetter fenland habitat. In the worse cases some habitats in our current priority habitat classification system are degraded versions of other habitats and have the potential to move between habitats and so abating carbon.

This layer has made a broad assessment of which land use may be changed to an appropriate higher carbon variant. In the case of very productive grassland and pasture we have assumed only a change to high carbon management practices where clear abatement gains are present. This is because high value agricultural land is a key non-renewable resource which is needed for food security. In addition, such land generates a good economic revenue for agricultural goods, so is less likely to change to a carbon economy.

Summary of Technical Description

This map was created differently to the others, by using a Python script to run the analysis. Firstly, a table was designed that looked at habitats and possible soil types they could develop upon. This was then used to create a logic table showing areas which were now not on suitable soil types, for example arable land on deep fen peat. Scoring was awarded using expert judgement by the team on the potential sequestration enhancement of each type of land management action or change. All the technical information is available in the accompany technical report.

Classes

The classes used in the abatement maps and models are shown in Table 1

Table 1: Note on action that could be taken related to approximate carbon abatement or carbon loss.

Code	Class	Notes
1	Maintain - enhance existing habitats	Some of our existing habitats for example, blanket bog vegetation deep peat, are not in the best ecological condition they can be. This is particularly the case for peatlands and heather moorlands which have been drained to change blanket bog vegetation into heathland vegetation or to obtain a grazing value out of the blanket bog. It was not in scope for this project to map this factor and therefore all areas of native vegetation occurring on appropriate soils types, have been marked as maintain/enhance existing vegetation. To understand if the condition needs to be enhanced a more detailed analysis on this aspect or a field visit is recommended.
2	Low carbon abatement or carbon loss	On productive agricultural land (intensive grassland and arable) there are possibilities to enhance carbon by changing land management practices to incorporate more organic matter and to prevent oxidation of the topsoil layers. Changing management practices, even a small amount, can result in a new increased carbon balance in the soil, benefiting not just climate change but soil health as well.
3	Low/medium abatement or carbon loss	This was given where the habitat could be replaced with a more suitable habitat, for example; • If heathland is found on deep peat, restoration of any drainage channels dug in the peat would allow bog vegetation to re-establish which is likely to sequester more carbon. • Where low productivity grassland, occurs on shallower soils then there is medium low likely increase if the grassland was managed to return to a semi-natural community. • Similarly, where improved grassland is returned to a semi-natural grassland a M/L increase in soil carbon would be expected
4	Medium carbon abatement or carbon loss	This is allocated where changing land use could result in a fairly good enhancement of carbon sequestration. Land was scored as medium where: • Coastal and flood plain grazing marsh, this was allocated the score in its entirety due to no data being available on different grassland and wetland

Code	Class	Notes
		types within the PHI. However, returning to wetland would produce good carbon benefits so taken as a while a medium score was awarded. • Where there is bracken, and scrub medium was awarded, in these habitats replacing the tree canopy layer will add to the carbon sequestration as they are often understory habitats in woodlands. • Marshy grasslands (categorised as Living England type fen marsh and swamp) can be enhanced to specie rich marshy grassland and or to wet woodlands giving a medium carbon abatement score
5	Medium high carbon abatement or carbon loss	This was awarded where the likely carbon abatement would be good, for example: • all bare ground was awarded a M/H as re-establishing a natural vegetation cover would significantly enhance the carbon outcome. • All low productivity grasslands (Natural England type 'Acid, Calcareous, Neutral grassland') on soil suitable for native woodland may have the potential for planting of native woodland and were therefore awarded a good score.
6	High carbon abatement & carbon loss	The highest benefits to carbon abatement are restoring the fenlands which are currently under arable and intensive grazing where carbon loss is extremely high.
7	Urban	It was not in scope for this project to look at carbon values in urban areas as the data accuracy is to poor too make an informed decision.
8	Water	It was not in scope for this project to look at carbon values within water bodies as the data accuracy is too poor to make an informed decision.

Using this layer

This layer will help you identify some of the strategic opportunities in your area for positive change and work out plans with land managers to enhance carbon, whatever the current land use. It will help you understand whether you are aiming to increase carbon by a smaller amount over a large area or concentrate on a couple of smaller schemes where there will be a large enhancement such as tree planting on low intensity (species poor) grassland.

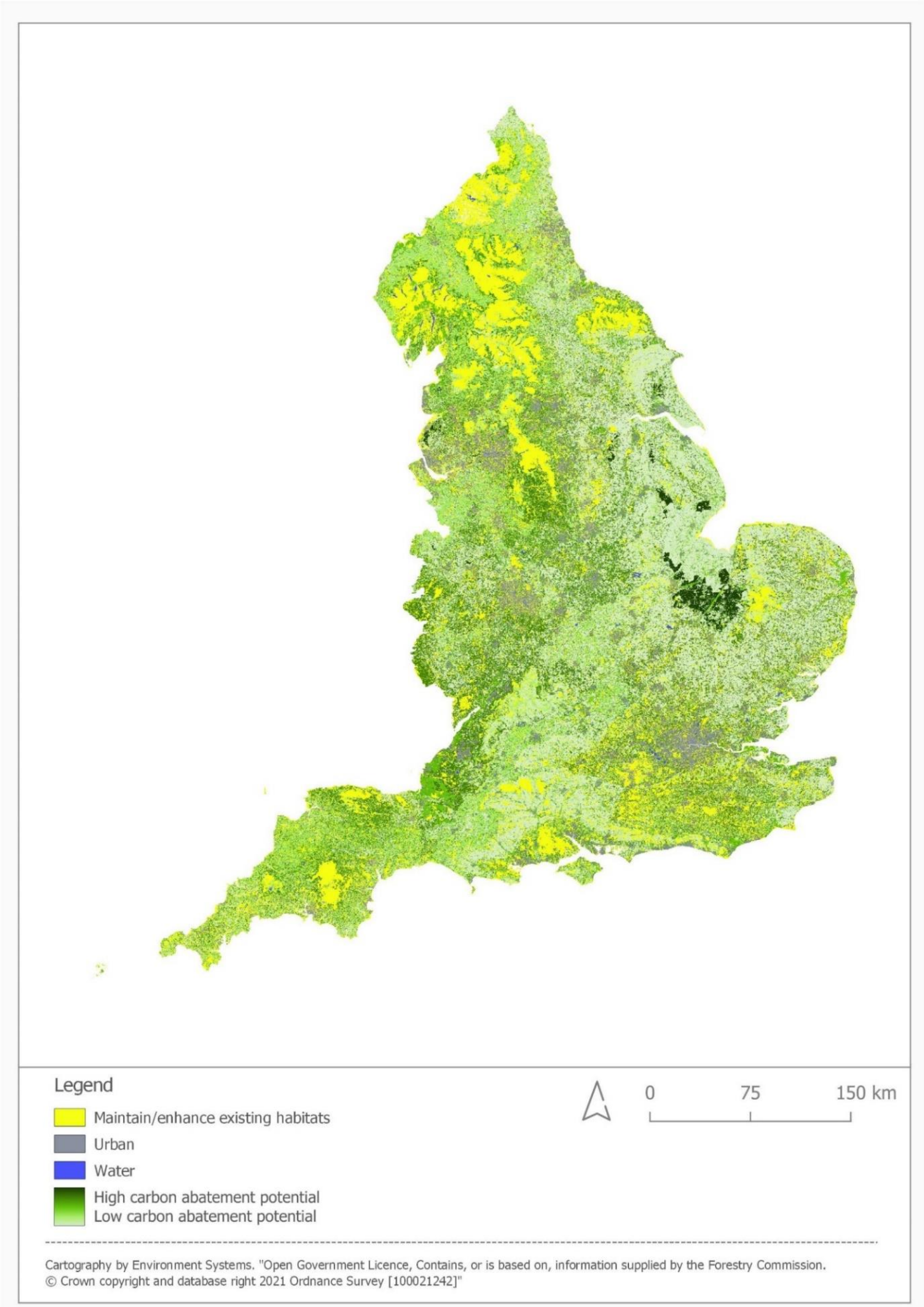

Figure 5: Carbon abatement

Approximate your carbon storage for an area

The C t ha^{-1} values within gridded data can be used to estimate total C for a given area using GIS tools. Using a raster calculator enter the following equation:

$$\frac{Layer \times 25^2}{10{,}000}$$

(Layer times 25 squared, divided by 10,000)

Then, using a zonal statistics tool, sum the output values that fall within the given area.

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