Natural England Commissioned Report NECR214

Developing Datasets for Biodiversity 2020: Outcome 1D (Omnicom 24951/ITT455)

First published 13 September 2016

www.gov.uk/natural-england

Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

Degradation makes ecosystems more vulnerable to climate change. In some cases, such as deforestation and erosion of peatlands, it releases carbon dioxide to the atmosphere contributing to greenhouse gas emissions. There is increasing recognition that restoring degraded ecosystems is an important element of climate change adaptation and mitigation.

The Biodiversity 2020 strategy for England includes a *commitment to restoring at least 15% of degraded ecosystems as a contribution to climate change mitigation and adaptation* (outcome 1D).

The Terrestrial Biodiversity Group (TBG), which includes members from a range of organisations, established a Task and Finish Group to look at how outcomes 1C & 1D of the Biodiversity 2020 strategy could be realistically implemented. The technical report presented here was commissioned to help deliver and create understanding around outcome 1D.

The outcome has its origin in the CBD Aichi targets, in particularly Target 15; *by 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification*. This forms part of Strategic goal D - enhance the benefits to all from biodiversity and ecosystem services.

After an initial scoping paper to agree context a subsequent paper to TBG recommended in September 2013 that more work was needed to create a baseline of which 15% could be measured from. As such a contract was let to develop a baseline for wetland and coastal ecosystems.

The particular issues that needed to be grappled with when developing thinking around Outcome 1D was:

- What are the key locations or ecosystems in England to initially concentrate on that will deliver the best climate change adaptation and mitigation outcomes by 2020?
- What is a degraded ecosystem when applied to England?
- As the target specified to deliver at least 15% of the area, a way of developing a baseline around what has been degraded by 2010 would be needed, how best to do this pragmatically so delivery is effective by 2020.

A key issue was how to shift from habitat based metrics to the wider aspects of the ecosystem as set out by the CBD - *A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit*. It was therefore important to bring in a functional component (the processes by which components of an ecosystem interact) that involves the abiotic (pH, soil, hydrology, climate, geology, geomorphology, temperature, salinity etc.) and how this could be better understood to support the biotic elements.

This report and the data created behind it investigate these complex issues and propose a practical solution that allows us to develop a spatial understanding of degraded ecosystems across the whole of England. This is intended to set the baseline of how outcome 1D would be approached and be measured. The delivery of outcome 1D as a new target will develop between now until 2020 as our understanding increases around ecosystems and the impacts of climate change on them. The ambition is to deliver ecosystem restoration that will reduce impacts on our natural environment and society through making both more resilient to the changes ahead.

Natural England Project Manager - Ian Crosher, Terrestrial Biodiversity, Ecological Networks Team
Correspondants Address: Mail Hub, Natural England, County Hall, Spetchley Road, Worcester,WR5 2NP
Ian.Crosher@naturalengland.org.uk

Contractor - AMEC Environment & Infrastructure UK Limited Canon Court, Abbey Lawn, Abbey Foregate, Shrewsbury SY2 5DE, United Kingdom

Keywords - Biodiversity 2020, outcome 1D, ecosystems, degraded ecosystems, climate change, adaptation, mitigation, resilience, restoration, function, functional approach, ecosystems approach, wetlands, peatlands, peat, coastal

Further information
This report can be downloaded from the Natural England website: **www.gov.uk/government/organisations/natural-england**. For information on Natural England publications contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk**.

ISBN 978-1-78354-357-1

amec

Natural England

Developing Datasets for Biodiversity 2020: Outcome 1D (Omnicom 24951/ITT455)

AMEC Environment & Infrastructure UK Limited

Natural England

Developing Datasets for Biodiversity 2020: Outcome 1D (Omnicom 24951/ITT455)

AMEC Environment & Infrastructure
UK Limited

Main Contributors

Graham Morgan
Jon Brown
Neil Thurston
Andrew Brooks

AMEC Environment & Infrastructure

UK Limited

Canon Court, Abbey Lawn, Abbey Foregate,
Shrewsbury SY2 5DE, United Kingdom
Tel +44 (0) 1743 342 000
Fax +44 (0) 1743 342 010

Executive Summary

Project Summary

Biodiversity 2020 (Defra, 2011) outlined the Government's strategy for biodiversity conservation in England, with a series of outcomes to be achieved by 2020. Outcome 1 states that:

> *"By 2020 we will have put in place measures so that biodiversity is maintained and enhanced, further degradation has been halted and where possible, restoration is underway, helping deliver more resilient and coherent ecological networks, healthy and well-functioning ecosystems, which deliver multiple benefits for wildlife and people including:*
>
> ***Outcome 1A**. Better wildlife habitats with 90% of priority habitats in favourable or recovering condition and at least 50% of SSSIs in favourable condition, while maintaining at least 95% in favourable or recovering condition;*
> ***Outcome 1B**. More, bigger and less fragmented areas for wildlife, with no net loss of priority habitat and an increase in the overall extent of priority habitats by at least 200,000 ha;*
> ***Outcome 1C**. By 2020, at least 17% of land and inland water, especially areas of particular importance for biodiversity and ecosystem services, conserved through effective, integrated and joined up approaches to safeguard biodiversity and ecosystem services including through management of our existing systems of protected areas and the establishment of nature improvement areas;*
> ***Outcome 1D**. Restoring at least 15% of degraded ecosystems as a contribution to climate change mitigation and adaptation".*

This project has been undertaken to inform Outcome 1D but the outputs are expected to contribute to the Outcome 1B target also in respect of the requirement to increase the overall extent of priority habitats by at least 200,000 ha. In this report degraded habitat has been interpreted as habitat that can be shown has been lost compared to the baseline used.

The key objectives of this Outcome 1D project were:

- To establish a baseline area of 'potential' key priority habitats for climate change. These are areas of potential woodland, wetland and coastal habitats, which do not currently qualify as priority habitat but could be restored to priority habitat status (c.f. Outcome 1B);

- To assess the relationship between habitat condition and key ecosystem functions such as carbon sequestration and storage;

- To develop a system for mapping degraded ecosystems to facilitate spatial analysis by Natural England staff to identify key locations for restoration and to assess progress of the 1D target.

The outputs against these objectives were achieved following the process outlined in Plate 1.

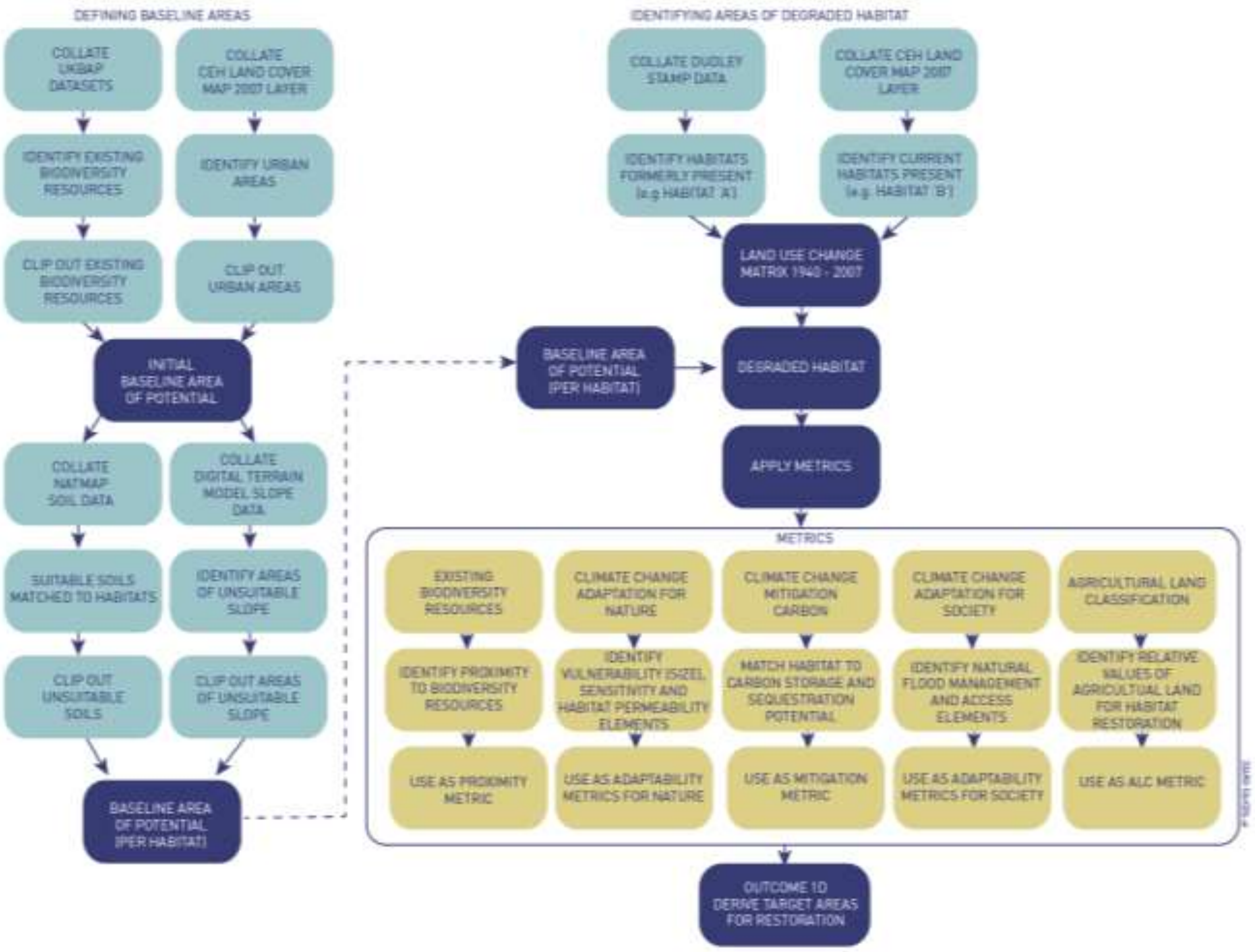


Plate 1 **Overview of the Process to Identify Target Areas for Outcome 1D**

Nine priority habitats were initially included in this project: coastal saltmarsh, coastal sand dunes, coastal vegetated shingle, maritime cliffs & slopes, coastal and floodplain grazing marsh, blanket bog, lowland raised bog, lowland fens and reedbeds. Traditional orchards were a late addition to the project, and were included in respect of analysis of extent of degraded habitat because they are mapped as an individual habitat in the 1940s Dudley Stamp data. Woodland and standing/ flowing water wetland UK priority habitats were excluded from this baseline dataset project because Natural England plan to rely on Forestry Commission and Water Framework Directive data respectively to consider these habitat types.

A fairly simple approach has been adopted to the identification of baseline areas of potential for each habitat using combinations of suitable soil types, slope conditions and floodplain locations to identify areas of habitat potential. The approach adopted is very similar to that, and uses some of the same environmental conditions, in the Wetland Vision project (Hume, 2008). However for some types of fen, notably groundwater fend fens, the Wetland Vision project undertook additional steps not repeated in this project. As a result, the fen potential areas developed in this Outcome 1D project are most similar to the Wetland Vision floodplain and eutrophic fens category. The implication of the differences in approach between the two projects is that some potentially suitable areas for fen, particularly those overlying aquifers, are omitted from the Outcome 1D datasets. This said, it is considered that the similarity between the fen potential areas developed in this project and those of the Wetland Vision floodplain and eutrophic fens category is the most useful in respect of the ability to create/restore habitat in the next 8 years.

The extent of baseline habitat potential for the target habitats was calculated as about 3.6 million ha, or about 28% of England.

Areas of degraded habitat have been derived by comparing habitat data from the 1940s (as represented by the Dudley Stamp dataset), with the Land Cover 2007 dataset and then cross-matching the results to areas of habitat potential. The analysis revealed that, following removal of blocks of less than 1ha in area, the extent of degraded habitat is 947,484 ha (ca 7.3% of England). As a result an indicative estimate of 15% target equates to about 142,122 ha (ca 1.1% of England). Although the Dudley Stamp dataset has limitations, it was considered the best available against which to define a baseline position. A further limitation on the analysis reported here is that orchards have only been included as degraded habitat where they coincide with areas of other habitat potential as a specific habitat potential layer for orchards was not derived. If Natural England wanted to focus efforts on orchards however it would be a straightforward task to simply compare the distribution of orchards as represented in the Dudley Stamp dataset and compare this with the current BAP inventory. Comparison of the two indicates that 72,000 ha that were orchard in 1940 have been lost and that while only 3,500ha that were orchards in 1940 still are, the Land Cover 2007 data indicates that there are 17,700 ha of orchards still in existence – so there has been some development of new areas since 1940. An additional consideration is that areas that were orchard in the 1940's are likely, by now, to have degraded unless replanted as fruit trees have a finite lifespan.

There is however clearly a need to target areas of restoration action to the lost suitable areas. To inform this targeting process six metrics have been defined to reflect current policy drivers (such as climate change) and also principles such as consideration of distance to existing biodiversity resources and the likely requirement to avoid restoring habitat on high grade agricultural land. The metrics were:

- Proximity to existing biodiversity;
- Climate change (carbon) mitigation;
- Climate change adaptation for nature (vulnerability);
- Climate change adaptation for society (flood risk)
- Climate change adaptation for society (access);
- Agricultural land classification.

The GIS analysis using these metrics weighted them all equally. The highest scoring 15% (by area) of degraded habitat is indicated by metric scores of 21 (covers highest scoring 12.5%) – 22 (covers highest scoring 18.5%). The top 15% based on metric scores falls between 117,702ha and 175,257ha. The most abundant habitats by area were coastal and floodplain grazing marsh, fen and a combination of these two with reedbed.

The ease of creation of habitats has been ranked based on the method developed by Entec (2009). Blanket bog and lowland raised bog are the hardest to create whilst reedbed is the easiest. Had orchard been specifically included in this analysis it would likely have been ranked as the easiest to create.

The potential cost of restoring the degraded habitat has also been assessed. The overall cost for creating and managing 15% priority habitats over a 5 year period (without land-purchase or landowner compensation costs) is estimated to be in the region of between £383 and £541 million corresponding to a total created area of between 117,702 and 175,257 hectares respectively. If land purchase costs are included these figures jump to between £2.4 and £3.5 billion. These are clearly significant sums which do not specifically include the costs of the local studies that would likely be required to support the restoration actions.

A number of project uncertainties have been highlighted and as a result, care will be required in the interpretation of the outputs. Suggestions have been made below for further work that could reduce uncertainty in the outputs.

Project suggestions

A number of suggestions arise from the work undertaken for this study and these are detailed below.

- To address the differences between this project and the Wetland Vision in respect of the distribution of groundwater fed fens, it is suggested that further development of the Outcome 1D model derived through this project could be undertaken to incorporate hydrogeological information. However, given the very large extent of fen potential habitat defined by the Wetland Vision, it is recommended that a similar but amended approach should be developed to ensure that potential for base rich groundwater fed fens and base poor groundwater fed fens are accounted for in the analysis, without over-representing the potential extent possible;

- The imminent release of the single layer BAP habitat inventory may result in changes to the areas that are clipped from the dataset at the outset, and hence the areas of potential identified. The model could be amended to include the single BAP layer instead of the many different layers that were used in this project;

- The model could be developed to take account of climate change insofar as there will be areas of potential habitat that are subsequently lost to coastal erosion, sea level rise etc. It may be possible to include these considerations such that areas are not targeted where these additional pressures are likely. Reference could be made to the Entec (2009) and the Environment Agency Shoreline Management Plans to inform this development;

- Using the GIS project supplied with this project Natural England's GIS experts could use the individual metrics (e.g. the proximity to biodiversity metric) to target specific areas or regions for restoration action. Additionally, the weightings applied to each of the metrics could be altered to place greater weight on one metric compared to another. In this project to date an equal weighting has been applied to each of the metrics. However, it is possible that current or future policy or climate change drivers may elevate the importance of one or more metrics over others in which case re-analysis applying different weighting may be desirable/ beneficial;

- If Natural England wanted to focus efforts on orchards specifically a comparison could be made, using the GIS data collated during this project, of the distribution of orchards as represented in the Dudley Stamp dataset with the current orchard BAP habitat inventory. This would highlight areas of lost habitat that could be targeted directly;

- The project or approach could be developed further, to assess the value of the habitats in respect of wider ecosystem services e.g. provisioning or supporting services, in addition to those implicitly covered by the metrics already developed in this project.

Contents

x

1. Background

1.1 Biodiversity Conservation and Climate Change

The English landscape and its inherent habitats and ecosystems have been dramatically shaped by the naturally fluctuating climate and anthropogenic human activity that has occurred for thousands of years. However the extent and pace of change has been considerably more dramatic since circa 1750 following key historical events in human history such as the agricultural and industrial revolutions, both World Wars, and post-war development when agricultural intensity and productivity increased, and significant changes in land-use occurred.

The introduction of nature conservation legislation and biodiversity policies over the last 30 years to designate, protect and enhance wildlife sites, species and habitats, and more recently, ecosystems, has gone a considerable way to redressing the changes that occurred (e.g. the success of Agri-environment schemes as reviewed in Natural England, 2009), and particularly since the Rio Convention on Biological Diversity of 1992. Nonetheless, it is widely acknowledged that more needs to be done, particularly in the face of climate change as noted by Lawton (2010) in the *Making Space for Nature – A Review of England's Wildlife Sites and Ecological Network*:

> *''England's collection of wildlife sites, diverse as it is, does not comprise a coherent and resilient ecological network even today, let alone one that is capable of coping with the challenge of climate change and other pressures''*

In addition, the recently released State of Nature (Burns *et. al*, 2013) quantifies the effects on the UK's species over the last 50 years, which are considered to be attributable to climate change and associated factors:

> *''...of 3,148 species...60% of species have declined over the last 50 years and 31% have declined strongly.*
> *Half of the species assessed have shown strong changes in abundance or distribution, indicating that environmental changes are having a dramatic impact on the nature of the UK's land and seas*
>
> *The threats to the UK's wildlife are many and varied, the most severe acting either to destroy valuable habitat or degrade the quality and value of what remains. Climate change is having an increasing impact on nature in the UK. Rising average temperatures are known to be driving range expansion in some species, but evidence for harmful impacts is also mounting...''*

1.2 Biodiversity and Climate Change Policy

1.2.1 Global

The tenth Conference of the Parties (CoP10) to the Convention on Biological Diversity (CBD) held in Nagoya in 2010, led to the adoption of a Global Strategic Plan for Biodiversity 2011-2020 (Anon, 2010)[1]. The Plan includes a 2050 vision, a 2020 'mission' and 20 targets known as 'Aichi Biodiversity Targets').

Target 15 of the global Plan states ''*By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks have been enhanced, through conservation and restoration, including restoration of at least 15 per cent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.*''

1.2.2 Europe

The EU 2020 Biodiversity Strategy (European Commission, 2011) is the European Union's response to the mandate given by the global Strategic Plan for Biodiversity 2011-2020, ensuring that the European Union meet its own biodiversity objectives and its global commitments.

Action 5 of the EU 2020 Biodiversity Strategy (European Commission, 2011) calls on Member States to map and assess the state of ecosystems and their services in their national territory with assistance provided by the European Commission. The European Commission Technical paper 'Mapping and Assessment of Ecosystems and their Services 2013 - 067' provides and supports the development of a coherent analytical framework to be applied by the EU and its Member States in order to ensure consistent approaches are used (European Commission, 2013).

Augmenting the European Commission approach to the mapping and assessment of ecosystem services, the EU Restoration Prioritisation Frame Work (Arcadis, 2013) provides a framework of criteria (thresholds and indicators) to define the magnitude of degradation and restoration potential for ecosystems enabling strategic priority-setting for nature conservation action at the sub-national and national levels.

Target 2 of the EU 2020 Biodiversity Strategy (European Commission, 2011): ''*focuses on maintaining and enhancing ecosystem services and restoring degraded ecosystems by incorporating green infrastructure in spatial planning. This will contribute to the EU's sustainable growth objectives19 and to mitigating and adapting to climate change, while promoting economic, territorial and social cohesion and safeguarding the EU's cultural heritage. It will also ensure better functional connectivity between ecosystems within and between Natura 2000 areas and in the wider countryside*''.

[1] Available at http://www.cbd.int/sp/default.shtml

1.3 United Kingdom

Subsequent to the Making Space for Nature report, and recognising the requirement for EU Member States to implement the targets and actions of EU 2020 Biodiversity Strategy within their respective countries, *Biodiversity 2020 (Defra, 2011)* outlined the Government's strategy for biodiversity conservation in England, with a series of outcomes to be achieved by 2020. Outcome 1 states that:

> *''By 2020 we will have put in place measures so that biodiversity is maintained and enhanced, further degradation has been halted and where possible, restoration is underway, helping deliver more resilient and coherent ecological networks, healthy and well-functioning ecosystems, which deliver multiple benefits for wildlife and people including:*
>
> ***Outcome 1A**. Better wildlife habitats with 90% of priority habitats in favourable or recovering condition and at least 50% of SSSIs in favourable condition, while maintaining at least 95% in favourable or recovering condition;*
> ***Outcome 1B**. More, bigger and less fragmented areas for wildlife, with no net loss of priority habitat and an increase in the overall extent of priority habitats by at least 200,000 ha;*
> ***Outcome 1C**. By 2020, at least 17% of land and inland water, especially areas of particular importance for biodiversity and ecosystem services, conserved through effective, integrated and joined up approaches to safeguard biodiversity and ecosystem services including through management of our existing systems of protected areas and the establishment of nature improvement areas;*
> ***Outcome 1D**. Restoring at least 15% of degraded ecosystems as a contribution to climate change mitigation and adaptation''.*

Outcome 1D therefore links directly back to Target 15 of the Global Strategic Plan for Biodiversity 2011-2020 (see Section 1.2.1).

A stakeholder steering group for the terrestrial biodiversity component of *Biodiversity 2020*, the Terrestrial Biodiversity Group (TBG), has commissioned a small number of Task & Finish Groups to provide advice on the interpretation and definitions of Biodiversity 2020 outcomes.

Investing in the improvement of wildlife and habitats can also improve the quality of life of people in many ways. Achieving benefits for people alongside biodiversity conservation is consistent with the central theme of the government's Natural Environment White Paper 'The Natural Choice – securing the value of nature' (HM Government, 2011) and builds on Defra's "*Delivering a healthy natural environment: An update to 'Securing a healthy natural environment: An action plan for embedding an ecosystems approach*" (Defra, 2010).

1.4 Outcome 1D

1.4.1 Aim and Definitions

Outcome 1D is to '*Restore at least 15% of degraded ecosystems as a contribution to climate change mitigation and adaptation*'.

Task & Finish Group 3 (TF3) has responsibility for overseeing delivery of Outcome 1D (and 1C) which includes the need to ensure that the Outcome is practically achievable – that mechanisms are available to implement it and that it does not conflict with other policy objectives for example on food security.

TF3 also recommend using the Convention on Biological Diversity's definition of ecosystems[2], but delimiting individual ecosystems according to semi-natural vegetation types, particularly priority habitats. TF3 considered this to be a pragmatic approach, consistent with other Biodiversity 2020 outcomes.

1.4.2 Degraded Ecosystems

In considering this Outcome TF3 assumed that 15% of degraded ecosystems would be interpreted as 15% of land in which ecosystems are degraded – however 'degraded' is defined (see Box 1) (Waters, 2012).

Box 1.1 **Definition of Degraded Habitat**
TF3 indicated that in other countries, restoring degraded habitat might be understood in terms of restoring recently lost or degraded ecosystems such as tropical forest or mangroves, which were largely intact before the second half of the 20th century. The interpretation is not so straightforward in the UK in which original vegetation cover was replaced millennia ago and in which many valuable semi-natural habitats were created by low intensity management. Nevertheless agricultural intensification and a range of other anthropogenic pressures have caused degradation of the UK's ecosystems, particularly over the course of the 20th century and there are opportunities to reverse this in ways which will particularly benefit climate change mitigation and adaptation. In this report degraded habitat has been interpreted as habitat that can be shown has been lost compared to the baseline used. Areas of existing priority habitat that are in degraded (unfavourable) condition are not included in the definition for this project because condition data are not available for the majority of priority habitat in England.

The Group recommended that in addition to improving the conservation status of priority habitats[3] (which will be carried out largely through the delivery of Outcome 1A – see Section 1), restoration and creation of habitats which are not currently considered as Priority Habitats (because they are degraded or non-existent) should be included in the delivery of Outcome 1D where possible. TF2, which has responsibility for Outcomes 1A, 1B and 3, define restoration as '*management of degraded habitat which no longer meets the qualifying criteria for priority habitat to return it to a state where it is considered to qualify as priority habitat*'. However as indicated in Box 1, this project has defined degraded habitat as

[2] See http://www.cbd.int/sp/default.shtml

[3] Priority Habitats in the context of Outcome 1D are those 39 terrestrial, freshwater and coastal habitats listed as of "principal importance" for the conservation of biological diversity in England under section 41 of the *Natural Environment and Rural Communities Act 2006*.

habitat that can be shown has been lost compared to the baseline used. This project is not therefore addressing restoration, as defined by TF2, but creation which TF2 refers to principally as 'expansion' and defines as follows: *'(sometimes also called 'creation') involves the establishment of priority habitat on land where it is not present and where no significant relicts of the habitat currently exist*'.

It is worth noting that the Outcome 1B requires '*More, bigger and less fragmented areas for wildlife, with no net loss of priority habitat and an increase in the overall extent of priority habitats by at least 200,000 ha* '. Outcome 1D is expected to contribute to the delivery of this expansion target as well as delivering the restoration of at least 15% of degraded ecosystems. However, in the context of the 1D target TF3 noted that there was the need for further work with respect to the establishment of the baseline extent of degraded habitat against which to measure the delivery of 15% ecosystem restoration (Waters, 2012).

1.4.3 Climate Change Adaptation and Mitigation

Climate change adaptation and mitigation have internationally agreed definitions as a result of the work of the Intergovernmental Panel on Climate Change. Biodiversity 2020 expresses these in simple terms.

- Climate Change Adaptation: helping to reduce the impacts of climate change.
- Climate Change Mitigation: addressing the causes of climate change by removing greenhouse gases from the atmosphere.

Mitigation in the context of the natural environment includes promoting the uptake of carbon dioxide by plant growth and reducing emissions of greenhouse gases from soils, for example from degraded peat bogs.

Adaptation should include taking advantage of any new opportunities that climate change presents, as well as reducing adverse impacts. It is also worth noting that adaptation in the context of biodiversity and ecosystems can include both actions that help species and ecosystems to adapt to climate change and using the natural environment to help society to adapt to climate change, for example by reducing flood risk.

TF3 (Waters, 2012) recommended that that in addressing this Outcome, '*climate change adaptation and mitigation should be interpreted in a broad way, to include:*

- reducing greenhouse gas emissions;
- promoting carbon sequestration by semi-natural habitats;
- adaptation of ecosystems themselves to maintain, and where appropriate, enhance biodiversity; and
- ecosystem-based adaptation for the benefit of people.

Given the context within Biodiversity 2020, mitigation or adaptation benefits for people should only be included in this Outcome if they also contribute to maintaining or enhancing biodiversity'.

1.5 Purpose of this Report

The key objectives of the project were, for Outcome 1D, to:

- establish a baseline area of 'potential' key priority habitats for climate change. These are areas of potential woodland, wetland and coastal habitats, which do not currently qualify as priority habitat but could be restored to priority habitat status (c.f. Outcome 1B);
- assess the relationship between habitat condition and key ecosystem functions such as carbon sequestration and storage;
- develop a system for mapping degraded ecosystems to facilitate spatial analysis by Natural England staff to identify key locations for restoration and to assess progress of the 1D target.

To address the objectives outlined above, this report describes:

- The data reviewed for use in this project (Section 2);
- How areas with potential to support priority habitats have been identified (Section 3);
- How areas of degraded habitat have been identified (Section 4);
- The ranking of areas of degraded habitat to target the highest scoring areas for restoration based on a series of metrics (Section 5), defined to enable Natural England to target areas based on the policy driver as follows:
  - Proximity to existing biodiversity;
  - Climate change (carbon) mitigation;
  - Climate change adaptation for nature (vulnerability);
  - Climate change adaptation for society (flood risk)
  - Climate change adaptation for society (access);
  - Agricultural land classification.
- The ease with which habitats can be transformed/restored (Section 6);
- Conclusions and Suggestions (Section 7).

The steps undertaken to identify baseline areas of potential, degraded habitat and application of metrics to identify target areas for Outcome 1D as described in Sections 3, 4 and 5 of the report are summarised in Plate 1.1.

A GIS project has been produced and supplied to Natural England as an outcome of this project.

It is envisaged that the output maps will be used by the relevant national and regional teams of Natural England to help focus local and regional nature conservation action on the ground to those areas that would make the most beneficial contribution to climate change adaptation and mitigation, as components of an overall co-ordinated national strategy.

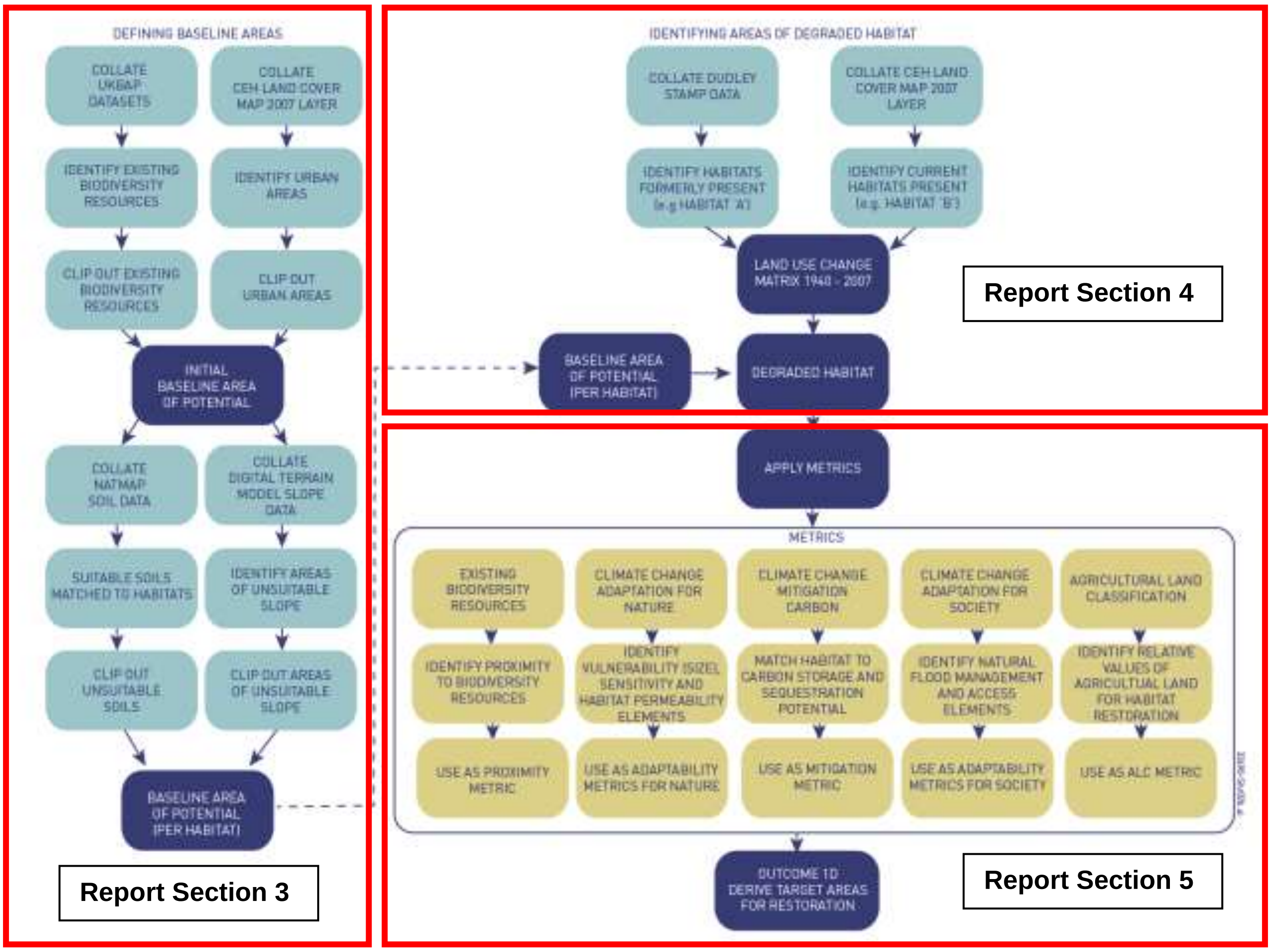


Plate 1.1 Overview of the Process to Identify Target Areas for Outcome 1D

1.6 Project Uncertainties

There are a number of areas of uncertainty in respect of the data used and in the interpretation of the outputs that merit highlighting. Awareness of these uncertainties has allowed the project team to address, or at least acknowledge them. Within the restraints of budget and timetable, the project has used the best nationally applicable datasets available, drawn on specialist knowledge of the project team, and made a number of assumptions to reduce uncertainty. Where uncertainties and data gaps remain, these are described in the report.

1.6.1 Data Sources and Interpretation

- There is significant uncertainty associated with the available national mapping of BAP habitats, as reported in Entec (2011). Additionally TF2, in its Definitions of Outcomes 1A, 1B and 3 Draft report, recognises the weaknesses in the inventories, although acknowledging that they remain the best available. TF2 recommends the creation of a single BAP habitat layer, which is now being tested within Natural England, but was not available for this project. The existing weaknesses in the inventories however mean that areas may have been clipped from the analysis that are not currently BAP habitat whilst the opposite may also be true with areas of BAP habitat not recognised in the inventories and hence identified as areas of potential;

- Identification of potential areas of habitat was undertaken using soils and slope data only. This is similar to the approach taken in the Wetland Vision project[4]. However there are a number of other factors that influence the nature of a habitat in any one location e.g. hydrological regime requirements, trophic status, level of exposure/shelter. It was however not possible, within the project timetable and budget, to derive a model to take account of these factors;

- The Dudley Stamp dataset has been used as the baseline dataset against which habitat changes have been assessed. Although it is useful in that it maps habitats present in the 1940s it also has limitations insofar as it only defined 8 habitat categories in total. These 8 will mostly therefore represent aggregations of habitats (e.g. the meadow and grass Dudley Stamp habitat will include calcareous grassland, acid grassland, improved grassland, neutral grassland and rough grassland as mapped in the 2007 Land Cover data). It is also notable that the Dudley Stamp dataset does not specifically map coastal habitats. Finally, although this dataset is presented as a seamless dataset, it is important to note that the quality of the scanned 1" base maps from which it was derived was variable with some categories more difficult to interpret than others (Entec, 2010). Nonetheless, this dataset was considered the most comprehensive and suitable for use in this study;

- It was not possible to define the condition of habitats degraded and therefore requiring restoration. The definition of degraded habitat used was therefore habitat that can be shown has been lost compared to the baseline used.

1.6.2 Interpretation of Outputs

- The project has used national datasets. There are inevitably issues with the resolution and accuracy of different datasets. The outputs should therefore be interpreted as giving a general indication of the scale of habitat restoration required to meet Outcome 1D and the likely best areas to deliver this. The outputs (baseline areas of potential, areas of degraded habitat etc.) should not however be interpreted as definitive as there will likely be a margin for error, meaning that when looked at on a local basis, other land parcels in the same area may also present themselves as suitable;

- Related to the point above regarding not interpreting the final dataset as definitive, it is important to remember that detailed studies of sites will be required at a local level to further

[4] http://www.wetlandvision.org.uk/

assess their suitability for specific habitats. For example, hydrological studies will be required before the restoration/ creation of any of the wetland habitats is an area is attempted;

- Due to data licensing issues it was not possible to directly include the Wetland Vision GIS data, which includes analysis of historic wetland areas and potential wetland areas, in this project. Data licensing allowed for visual comparison only (see Section 3.4.2 for further comment);

- The feasibility of restoring (creating) habitats that would meet the BAP habitat definitions. Although it is possible to define the likely required conditions for establishment of a BAP habitat there is no guarantee that it would develop to a habitat that matches the BAP habitat definition;

- The analysis has not taken account of climate change insofar as there will be areas of potential habitat that are subsequently lost to coastal erosion, sea level rise etc.;

- A limitation on the analysis reported is that, as orchards were added mid way through the project, they have only been included as degraded habitat where they coincide with areas of other habitat potential as a specific habitat potential layer for orchards was not derived. If Natural England wanted to focus efforts on orchards however it would be a straightforward task to simply compare the distribution of orchards as represented in the Dudley Stamp dataset and compare this with the current BAP inventory.

2. Review of GIS Datasets

2.1 Datasets

The first main task undertaken in the project was a major data collection exercise to obtain a series of GIS data layers which could be used to develop the potential habitat layers and/or develop the metrics to prioritise areas for future investigation. The characteristics of the key layers obtained in the study are summarised below in Table 2.1.

Table 2.1 GIS Datasets Collected and Reviewed

Dataset	Source*	Description	Expected Use within the Study	Actual Use of the Dataset
Agricultural Land classification national datasets	NE	Agricultural land grade (Grade 1-5) National resolution	Identification of areas of lower agricultural suitable and hence more likely for habitat restoration	Dataset used in the development of the Agricultural Land Classification Metric
Agricultural Land classification - detailed	NE	Partial dataset of detailed ALC mapping held by Natural England	See above	Incomplete national coverage meant that this dataset was not used in the study
Areas of Outstanding Natural Beauty	NE	Areas of Outstanding Natural Beauty	Used to identify areas which have additional access value for society	Data layer used in value for society – access potential metric
BAP habitat designations	NE	Core habitat datasets produced from aerial photography interpretation 2003-2008 The habitat layers considered were Ancient Woodlands, Blanket Bog, Coastal & Floodplain Grazing Marsh, Coastal Sand Dunes, Coastal Vegetated Shingle, Deciduous woodland, Fens, Limestone Pavements, Lowland Calcareous Grassland, Lowland Dry Acid Grassland, Lowland Heathland, Lowland Meadows, Lowland Raised Bogs, Maritime Cliff and Slope, Mudflats, Purple Moor Grass Rush Pastures, Reedbeds, Saltmarsh, Saline Lagoons, Traditional Orchards HAP, Upland Calcareous Grassland, Upland Hay Meadow, Upland Heathland and Woodpasture & Parkland	Use as core baseline dataset for priority habitats and to identify target areas (i.e. linked/close proximity) of potential areas for restoration	Used to remove/clip areas of existing BAP habitats from the potential habitat layers created in the study
Boundary Line	OS	OS core product of administrative boundaries	Used to limit spatial analysis to the boundary of England	Use in GIS operation to clip and mask final habitat potential and degraded habitat layers.
Biosphere reserves	NE	Dataset showing the location of biosphere reserves across England	Used to identify areas which have additional access value for society	Data layer used in value for society – access potential metric

Table 2.1 (continued) GIS Datasets Collected and Reviewed

Dataset and Provider	Source*	Description	Expected Project Use	Use of dataset within the study
Countryside Survey	CEH	GIS and database files showing the extent of different land use and habitat types across UK from 1978 – 2007. Variety of different survey/GIS datasets at variable resolutions	Potential use to assess global changes in land use and habitat status, especially since 1978. However datasets likely to be used primarily for context.	This dataset was reviewed but not used in the study.
Digital Elevation Model (Flood Map for Surface Water DTM)	EA	1:10 or 1:50k scale digital elevation model(grid)	Use as input layer for identification of more suitable areas of some habitats (grazing marsh etc)	Dataset used as an input into the creation of the Coastal Floodplain Grazing Marsh habitat potential layer
Digital River Network (DRN)	EA	Detailed dataset showing location of current water features (rivers, canals)	Context information and identification of wetland habitat restoration	This dataset was reviewed but not finally used in the study.
Dudley Stamp Historical Land Use Maps	EA/NE	1930s classified historical land use (8 categories) information for England	Used to identifying previous areas of woodland and wetland which have been subsequently been converted to alternative land uses	Dataset used in combination with the Land Cover map 2007 to identify areas of potential habitat which have been lost to other land uses since 1940.
Forestry Commission Estate Legal Boundary	FC	Forestry Commission Estate Legal Boundary	To delimit areas of existing woodland	This dataset was reviewed but not used in the study.
Forestry Commission Woodland Inventory	FC	Detailed dataset of native and non-native woodland coverage	GIS queries to remove existing areas of woodland from priority habitat layers	Dataset used to remove areas of woodland from BAP habitat potential
Flood Risk Management Programme / FloodMap	EA	Areas of inland and coastal flood risk	Identification of areas of potential wetland habitat creation – needs cross referencing with available information of proposed flood management schemes – especially habitat creation	
Historic parks and gardens	EH	Dataset showing recorded location of historic parks and gardens	Used to identify areas which have additional access value for society	Data layer used in value for society – access potential metric
National Coastal Erosion Risk Mapping	EA	GIS datasets showing locations of protected and unprotected coastal plus estimates of future coastal erosion rates	Potential use in identifying areas which are expected to be protected and stable under future climate change scenarios and hence worth targeting for habitat creation/restoration.	
National Land Cover Map 2007 (LCM2007)	CEH	Detailed remote sensing derived land use information (23 individual classes)	Identification of target areas of inland water and woodland located in close proximity to existing priority habitats	Dataset used in combination with the Dudley Stamp LUS layer to identify areas of potential habitat which have been lost to other land uses since 1940.

Table 2.1 (continued) GIS Datasets Collected and Reviewed

Dataset and Provider	Source*	Description	Expected Project Use	Use of dataset within the study
National Coastal Erosion Risk Mapping	EA	GIS datasets showing locations of protected and unprotected coastal plus estimates of future coastal erosion rates	Potential use in identifying areas which are expected to be protected and stable under future climate change scenarios and hence worth targeting for habitat creation/restoration.	
National Land Cover Map 2007 (LCM2007)	CEH	Detailed remote sensing derived land use information (23 individual classes)	Identification of target areas of inland water and woodland located in close proximity to existing priority habitats	Dataset used in combination with the Dudley Stamp LUS layer to identify areas of potential habitat which have been lost to other land uses since 1940.
National Parks	EH	Location of National parks across England	Used to identify areas which have additional access value for society	Data layer used in value for society – access potential metric
National Soilscape Soil Data	Cranfield University	1:250,000 GIS dataset delimiting key soil characteristics across England	Identification of key soil types relevant to potential habitat creation / restoration	Main soil dataset used to identify suitable soils for each individual BAP habitat potential layer.
National Peat Resource Inventory	JNCC	Dataset showing pockets of peat at greater resolution than NatMap dataset	Used in parallel with soil and habitat dataset to identify potential target locations.	This dataset was reviewed and considered in development of the carbon metric
Open Access Land	NE	Areas of open access land across England	Used to identify areas which have additional access value for society	Data layer used in value for society – access potential metric
Registered Battlefields	EH	Dataset showing recorded location of designated registered battlefields	Used to identify areas which have additional access value for society	Data layer used in value for society – access potential metric
SSSI unit and condition	NE	Location and details of primary habitats and condition	Dataset used together with BAP habitat data to define existing priority habitats	Used by AMEC in a wide range of national policy and assessment studies but not for this study
Urban Settlements	OS	Location of key urban settlements stored in the OS Meridian data product	Used to prioritise non-urban areas in the analysis process.	Used to remove/clip areas of existing urban areas from the potential habitat layers
Wetland Vision	NE	Partnership project designed to outline the 50 year vision for wetlands in England. Outputs included a variety of wetland habitat opportunity maps developed using GIS analysis methods. Used complex processes and expert workshops to help define areas of wetland potential.	Access to the GIS datasets and models produced for the Wetland Vision to assist in the development of similar models during the project.	Used to help inform approach to identification of baseline potential areas. However, the datasets themselves were only available to use as a visual reference – they could not be included in the analysis.

Table notes: * CEH Centre for Ecology and Hydrology; EA Environment Agency; EH English Heritage; NE: Natural England; OS: Ordnance Survey; CEH Centre for Ecology and Hydrology; JNCC Joint Nature Conservation Committee; FC Forestry Commission

2.2 Review of Data Quality

As part of this review, the AMEC project team assessed the suitability of each of the datasets to help delimit target BAP habitat potential; degraded BAP habitat potential and ultimately identify priority areas for future delivery of the Outcome 1D target. The remainder of this section highlights the characteristics of the most important datasets used in the study and how these features ultimately influence the spatial resolution of the final GIS layers produced.

2.2.1 Existing BAP Habitat Layers

AMEC has prior experience of reviewing and manipulating the national and regional BAP datasets for Defra's 'Developing Tools to Evaluate the Consequences for Biodiversity of Options for Coastal Zone Adaptation to Climate Change' project. This work highlighted that the BAP habitat data available from Natural England were compiled from a series of other datasets, some of which were old and hence highly likely to now be unreliable.

For example, the primary source of data on the extent of Coastal and Floodplain Grazing Marsh is 'The Distribution of Lowland Wet Grassland in England (Dargie, 1993)'; whilst for reedbeds the key source is 'The Inventory of British Reedbeds (Painter *et.al*., 1995)'. Additionally, there is known to be some overlap in the data, albeit that some habitat overlap is allowed within the criteria for mapping that Natural England employs, and there is a considerable amount of uncertainty in the mapping of the available data. The results of this work concluded that

- Habitat mis-mapping and over-estimation of the habitat extents in the national datasets. The habitat mis-mapping and over-estimation is believed to be caused, at least partly, by the inclusion often of the same botanical communities in the definitions of more than one priority BAP habitat;
- Relatively low agreement between national and site specific data;
- Data overlaps leading to potential for double counting of areas and also the extensive mis-mapping of habitats remaining within the regional datasets.

TF2 additionally observed that '*One of the main problems with the current inventories is that they have usually been compiled on a habitat-by habitat basis, with the result that overlaps are common and hard to control for*'.

The potential inaccuracies of the BAP habitat layers must therefore be considered carefully when reviewing the outputs of this study. It is worth noting that Natural England is developing a single layer habitat inventory (i.e. all habitats contained within a single GIS layer) to eliminate overlaps. This will improve the consistency of figures used for reporting habitat extent within and outside SSSIs but was not available for this project.

2.2.2 Natmap Soilscape Data

The NatMap Soilscape dataset is a key input dataset used to develop the individual habitat potential layers, with its use/ application mirroring the approaches adopted within the Natural England Wetland Vision study. However the Soilscape dataset is only available at a relatively coarse spatial scale (1:250,000) and this is reflected in the scale of the individual habitat potential layers produced in the study.

2.2.3 Dudley Stamp LUS Land Use Map

The GIS version of the Dudley Stamp LUS land use maps was created by AMEC under a 2009 contract for the Environment Agency and Natural England. Further details of this dataset are provided later in this report. Although this dataset is presented as a seamless dataset, it is important to note that the quality of the scanned 1” base maps from which it was derived were variable. This variability contributes to spatial differences in the overall accuracy of the information contained in the final GIS dataset and ultimately the accuracy of the 1940-2007 land use change matrix used to develop the final degraded habitat potential layer produced in this study. This output is described in detail later in Section 4.

2.2.4 CEH Land Cover 2007 (LCM 2007) Map

The LCM2007 dataset was produced by remote sensing/ image processing of over 70 satellite images covering the UK. Although the outputs of this processing were subject to sampled quality review, the quoted accuracy of the final classification product is about 83% (based upon field validation of 9127 points). This characteristic is an additional factor which influences the spatial distribution of the 1940-2007 land use change layer and ultimately the final degraded habitat potential layer.

3. Areas with Potential to Support Priority Habitats

3.1 Which Priority Habitats to include

The Convention on Biological Diversity's Aichi Biodiversity Target 15[5] suggests three 'high-level (coarse) habitat groupings/ ecosystems that are considered to be the most beneficial for contributing to climate change adaptation and mitigation, coastal habitats, wetland habitats and woodland habitats. These three ecosystems can be subdivided into various UK priority habitats, which enable the link to be made with Outcome 1D, albeit not all UK priority habitats could be used.

The potential complication using woodland habitats was highlighted by TF3 in its Biodiversity 2020 Technical Paper (Waters, 2012):

''There are a number of complications...there are practical difficulties to using woodlands:

- Improving condition of woodlands may not make a significant contribution to their value to climate change adaptation or mitigation, as much action is focussed on improving the biodiversity of the ground layer;
- Non-native woodland also brings adaptation and mitigation benefits and its replacement with native woodland might release carbon in the short-medium term;
- Woodland creation has been a long-standing objective of forestry policy and is one of the most significant land management contributions to climate change adaptation and mitigation. This is reinforced by the recommendations of the Independent Panel on Forestry, which recommends an increase in the forest cover of England from 10 to 15% by 2060. For the purposes of Outcome 1D, however, it is hard to identify a suitable baseline of degraded area which would be restored by forest creation. Most of England's land surface was once forest, but was converted to other land uses. It is not likely to be widely acceptable to define a lowland heath or sustainably managed pasture as degraded forest;
- The future of Forestry policy is currently subject of some uncertainty, pending the government's response to the Independent Forestry Panel''.

In relation to standing and flowing water, TF 3 also highlighted:

> *"...there are practical difficulties.... In particular rivers are linear features and tend to be expressed in terms of length rather than area and restoration of freshwater systems requires intervention in at least some of the catchment. It is therefore difficult to establish a baseline degraded area, against which to judge 15% restoration''*

In addition, Natural England subsequently considered that[6]:

---

[5] Under the Strategic Plan for Biodiversity 2011-2020 (Anon, 2010) – see http://www.cbd.int/sp/targets/rationale/target-15/
[6] Confirmed during project meeting with Natural England project steering group on 7th January 2013.

- woodland should be excluded because the Forestry Commission's inventory/ datasets are considered accurate, reliable and a good basis for delivering 1D with regards to woodland;
- standing and flowing water should be excluded as measures to improve the ecological status of these would largely be delivered through the Water Framework Directive and River Basin Management Plans on a catchment-wide basis. TF2 had some concerns in this respect but concluded, under its Recommendation 6, that in the short term freshwater priority habitat condition should be linked to WFD standards. In the medium term (within 2 years), freshwater habitats should be assessed further to identify a sub-set that should in future be considered priority habitat for the purpose of Biodiversity 2020. The assumption used in this project is therefore appropriate at this time.

Woodland and standing/ flowing water wetland UK priority habitats were therefore excluded from this baseline dataset project. The nine priority habitats included in this project in respect of deriving areas of habitat potential are given in Table 3.1. Traditional orchards were subsequently included in the project, in respect of analysis of extent of degraded habitat, because they are mapped as an individual habitat in the Dudley Stamp data. However no specific area of habitat potential was derived because of the wide range of conditions upon which orchards can exist and because it is possible to directly compare the Dudley Stamp data with the current BAP inventory to derive an indication of how much orchard habitat has been lost.

Table 3.1 Priority Habitats included in this Project

Global Habitat Grouping Category/ Ecosystem (Aichi Target 15)[1]	Corresponding UK Broad Habitat Category[2]	Corresponding UK Priority Habitat	Further Habitat Sub-Division for the Project
Coastal	MH (Littoral Sediment)	Coastal saltmarsh	-
	T&FH (Supralittoral Sediment)	Coastal sand dunes	-
	T&FH (Supralittoral Sediment)	Coastal vegetated shingle	-
	T&FH (Supralittoral Rock)	Maritime cliffs & slopes	-
	T&FH (Improved grassland)	Coastal and floodplain grazing marsh	-
Wetland	T&FH (Improved grassland)		-
	T&FH (Bogs)	Blanket bog	-
	T&FH (Bogs)	Lowland raised bog	-
	T&FH (Fen, Marsh and Swamp)	Lowland fens	**Topography**: Topogenous and soligenous[3] **Nutrient status**: Base-poor fen, base-rich fen[3], other fen (nutrient status unknown)
	T&FH (Fen, Marsh and Swamp)	Reedbeds	-

Table 3.1 (continued) Priority Habitats included in this Project

Global Habitat Grouping Category/ Ecosystem (Aichi Target 15)[1]	Corresponding UK Broad Habitat Category[2]	Corresponding UK Priority Habitat	Further Habitat Sub-Division for the Project
Woodland	Various but not included (see Section 3.1)	Various but not included (see Section 3.1)	-

Table notes: [1] as prescribed by The Convention on Biological Diversity's Strategic Plan for Biodiversity 2011-2020 Aichi Biodiversity Target 15 (CBD, 2010); [2] MH: Marine Habitats; T&FH Terrestrial and Freshwater Habitats (available at www.jncc.defra.gov.uk); [3] based upon BRIG (2008, updated 2011).

Lowland Fen actually encompasses a range of plant communities/ 'sub-habitats' that occur in various topographical and nutrient-status situations, as per the priority habitat description for Lowland Fen (BRIG, 2008, updated 2011). On this basis, and by considering the type of soil data available, it was therefore considered appropriate to sub-divide lowland fen into two topographical categories ('topogenous' – on relatively flat topography; 'soligenous' – seepage faces on sloping ground), and three nutrient categories ('base-poor fen', 'base-rich fen', and 'other fen' (nutrient status unknown)).

3.2 Approach to identifying Areas with Potential for the Target Habitats and GIS Processing

3.2.1 Approach

To define the areas where the nine target habitats could feasibly be created, the following datasets were collated (as already described in Section 2.2):

- Existing biodiversity resources (designated statutory site data and UK BAP habitat data available at http://www.natureonthemap.naturalengland.org.uk/MagicMap.aspx);
- Land-use (cover) data (Centre for Ecology and Hydrology Land-cover Map 2007);
- Soil type data (NatMap soilscapes);
- Slope data (Ordnance Survey Digital Terrain Model).

An overview of the approach is given in Plate 3.1.

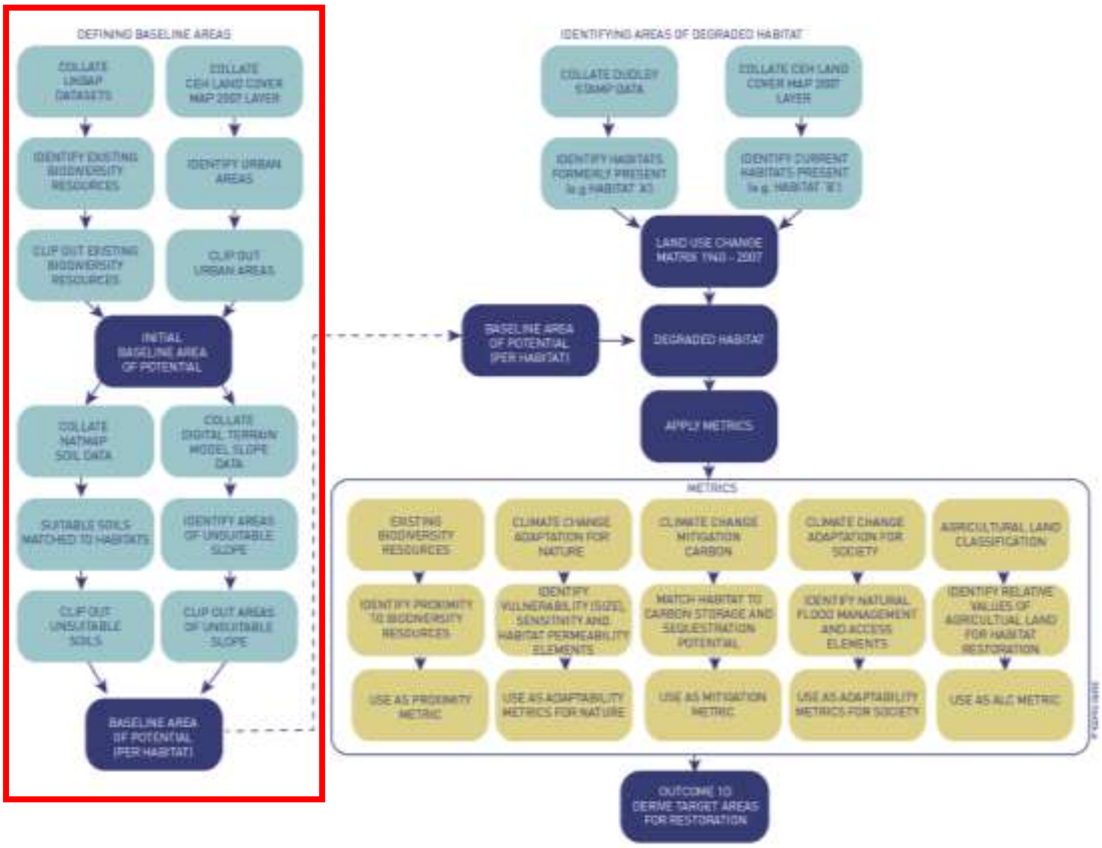


Plate 3.1 **Flowchart summarising the Process of identifying Baseline Areas of Potential Habitat**

3.3 GIS Processing

Identifying an Initial Baseline Area of Potential

An initial baseline area of potential was created for England. This comprised all land in England after urban areas, UK BAP habitats and designated sites had been clipped out. This was achieved by using an ArcGIS-Spatial Analyst Extract by Mask geoprocessing tool as shown in Plate 3.2.

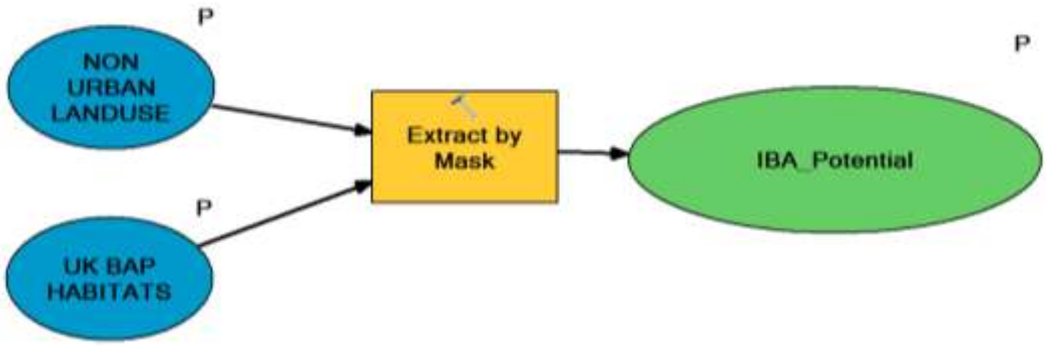


Plate 3.2 Model to Create Initial Baseline Area of Potential (IBA)

The list of UK BAP habitats and designated sites that were clipped out can be found in Table 3.2. This list included the 9 target BAP habitats and also 15 'Other' BAP habitats. The extent of urban area was defined as both Urban and Suburban class from the dataset CEH Land Cover map 2007.

Table 3.2 UK BAP Habitats and Designations

Target BAP Habitats	Other BAP Habitats	Designations
Blanket Bog	Ancient Woodlands (England –wide)	LNR
Coastal & Flood plain Grazing Marsh	Deciduous Woodland	NNR
Coastal Sand Dune	Limestone Pavements	RAMSAR
Coastal Vegetated Shingle	Lowland Calcareous Grassland	SAC
Fen	Lowland Dry Acid Grassland	SPA
Lowland Raised Bog	Lowland Heathland	SSSI
Maritime Cliff and Slope	Lowland Meadows	
Reedbed	Mudflats	
Saltmarsh	Purple Moor Grass Rush Pastures	
	Saline Lagoons	
	Traditional Orchards HAP	
	Upland Calcareous Grassland	
	Upland Hay Meadow	
	Upland Heathland	
	Woodpasture & Parkland	

Identifying a Baseline Area of Potential (Per Habitat Type)

A fairly simple approach has been adopted to the identification of baseline areas of potential for each habitat. The approach adopted is very similar to that, and uses some of the same environmental conditions, used in the Wetland Vision project (Hume, 2008). This comprised consideration of environmental conditions that support the target BAP habitats. Suitable soil types and suitable slope conditions were simply matched to each habitat type. Additionally, areas outside the floodplain (outside FloodMap Zones 2 and 3) were clipped out for reedbed and coastal and floodplain grazing marsh.

Consideration was given to defining an artificial derived 'supra-littoral zone' for the GIS model, for the coastal habitats[7], in an attempt to restrict the definition of potential areas for coastal habitats to the coastal area. This is because some of the potentially suitable soil types and slope occurred inland as well as at the coast and the Biodiversity Information Reporting Group (BRIG) definition of these coastal habitats (see Table 3.1) is that they occur within the supralittoral zone (BRIG, 2008, updated 2011). The supralittoral zone is the area above the spring high tide line, on coastlines and estuaries, that is regularly splashed but not submerged by ocean water. For the project, the supralittoral zone was defined as a generic 50m inland from the spring high tide mark, based upon professional judgement and experience, and the resolution of the data that were being used in the GIS model.

However, during the course of analysing the data in GIS, it became apparent that this approach resulted in suitable areas for all but one of the coastal habitats being excluded. It was therefore decided that the 50m supralittoral zone would only be applied to Maritime Cliffs & Slopes because these were the habitats that were truly restricted to a position closer to the sea than the other coastal habitats.

The factors used to refine the baseline areas of potential for individual habitats were identified based on information provided in guidance documents (Wheeler, Shaw, & Tanner, 2009; Wheeler, Shaw, Brooks and Whiteman, 2010; Holliday, 2008), others sources of information[8], as well as professional judgement and experience.

Table 3.3 summarises the conditions used to derive the baseline area of potential for each priority habitat.

[7] Coastal Saltmarsh, Coastal Sand Dunes, Coastal Vegetated shingle, Maritime Cliffs & Slopes
[8] The Environment Agency's Wetland Habitat Creation Programme Anglian Region GIS criteria and BRIG's UK BAP priority habitat descriptions available at www.jncc.defra.gov.uk.

Table 3.3 Environmental Conditions used to derive Baseline Potential for Each Habitat Type

Datasets and Sources Used	Factors Used /Suitable for Baseline Potential		
	Soilscapes Included	**Slope**	**Other Criteria Applied**
Coastal Saltmarsh	Saltmarsh soils	≤1% 1-3%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out
Coastal Sand Dunes	Sand dune soils	≤1% 1-3%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out
Coastal Vegetated Shingle	Saltmarsh soils Sand dune soils	≤1% 1-3%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out
Maritime Cliffs and Slopes	Freely draining acid loamy soils over rock Freely draining lime-rich loamy soils Freely draining slightly acid but base-rich soils Freely draining slightly acid loamy soils Freely draining slightly acid sandy soils Freely draining very acid sandy and loamy soils Lime-rich loamy and clayey soils with impeded drainage Loamy and clayey soils of coastal flats with naturally high groundwater Loamy and sandy soils with naturally high groundwater and a peaty surface Loamy soils with naturally high groundwater Naturally wet very acid sandy and loamy soils Shallow lime-rich soils over chalk or limestone Shallow very acid peaty soils over rock Slowly permeable seasonally wet acid loamy and clayey soils Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils Slowly permeable wet very acid upland soils with a peaty surface Very acid loamy upland soils with a wet peaty surface	>3%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out Occurring only within an artificially derived 'supralittoral zone' near the coast (50m inland from mean spring high-tide line)

Table 3.3 (continued) Environmental Conditions used to derive Baseline Potential for Each Habitat Type

Datasets and Sources Used	Factors Used /Suitable for Baseline Potential		
	Soilscapes Included	**Slope**	**Other Criteria Applied**
Coastal & Floodplain Grazing Marsh	Fen peat soils Freely draining floodplain soils Loamy and clayey floodplain soils with naturally high groundwater Loamy and clayey soils of coastal flats with naturally high groundwater Loamy and sandy soils with naturally high groundwater and a peaty surface Loamy soils with naturally high groundwater Slowly permeable seasonally wet acid loamy and clayey soils Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils	≤1%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out Areas outside the floodplain (outside Zones 2 and 3) clipped out
Blanket Bog	Blanket bog peat soils Slowly permeable wet very acid upland soils with a peaty surface Very acid loamy upland soils with a wet peaty surface	≤1% 1-3%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out
Lowland Raised Bog	Raised bog peat soils	≤1%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out
Lowland Fen (Topogenous)	**Base-rich fen** – Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils **Base-poor fen** – Slowly permeable seasonally wet acid loamy and clayey soils **Fen (undefined nutrient status)** – Fen peat soils Freely draining floodplain soils Freely draining slightly acid but base-rich soils Loamy and clayey soils of coastal flats with naturally high groundwater Loamy and clayey floodplain soils with naturally high groundwater Loamy and sandy soils with naturally high groundwater and a peaty surface Loamy soils with naturally high groundwater Naturally wet very acid sandy and loamy soils	≤1%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out
Lowland Fen (Soligenous)	**Base-rich fen** – Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils **Base-poor fen** – Slowly permeable seasonally wet acid loamy and clayey soils **Fen (undefined nutrient status)** – Fen peat soils Freely draining floodplain soils Freely draining slightly acid but base-rich soils Loamy and clayey soils of coastal flats with naturally high	1-3%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out

	groundwater Loamy and clayey floodplain soils with naturally high groundwater Loamy and sandy soils with naturally high groundwater and a peaty surface Loamy soils with naturally high groundwater Naturally wet very acid sandy and loamy soils		
Reedbed	Slowly permeable seasonally wet acid loamy and clayey soils Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils Loamy and clayey soils of coastal flats with naturally high groundwater Fen peat soils Loamy and clayey floodplain soils with naturally high groundwater Loamy and sandy soils with naturally high groundwater and a peaty surface Loamy soils with naturally high groundwater Naturally wet very acid sandy and loamy soils	≤1%	Urban and sub-urban land-use clipped out Existing UK BAP habitats and protected sites clipped out Areas outside the floodplain (outside Zones 2 and 3) clipped out

An example of a GIS model used to identify baseline area of potential for coastal and floodplain grazing marsh is provided below in Plate 3.3, with further models for each priority habitat presented in Appendix A.

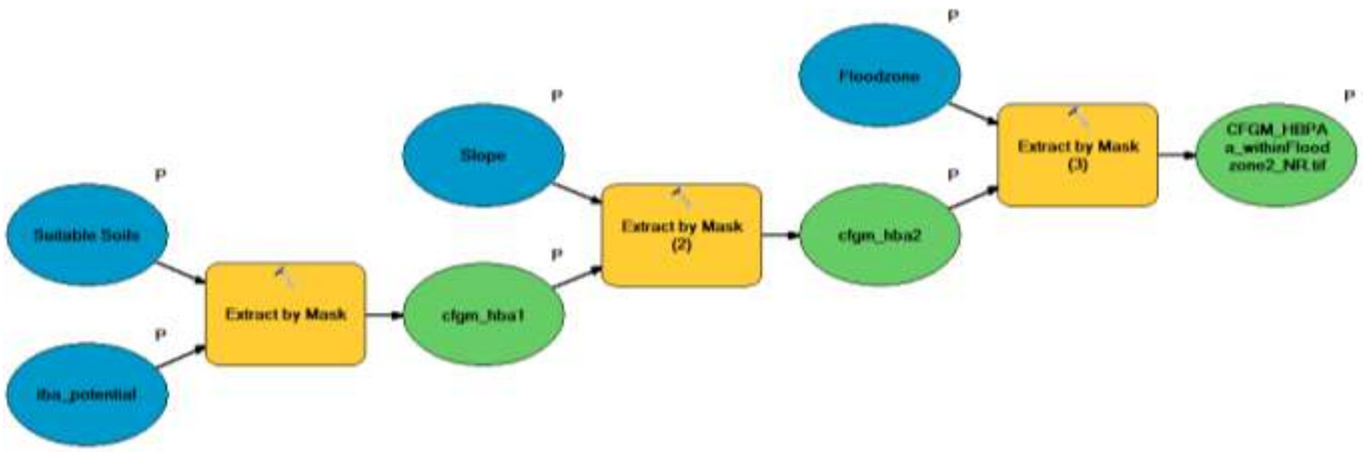


Plate 3.3 Geoprocessing Model for the Identification of Baseline Area of Potential for Coastal and Floodplain Grazing Marsh

Examples of the outputs for the identification of baseline area of potential are provided below in Plates 3.4 to 3.7.

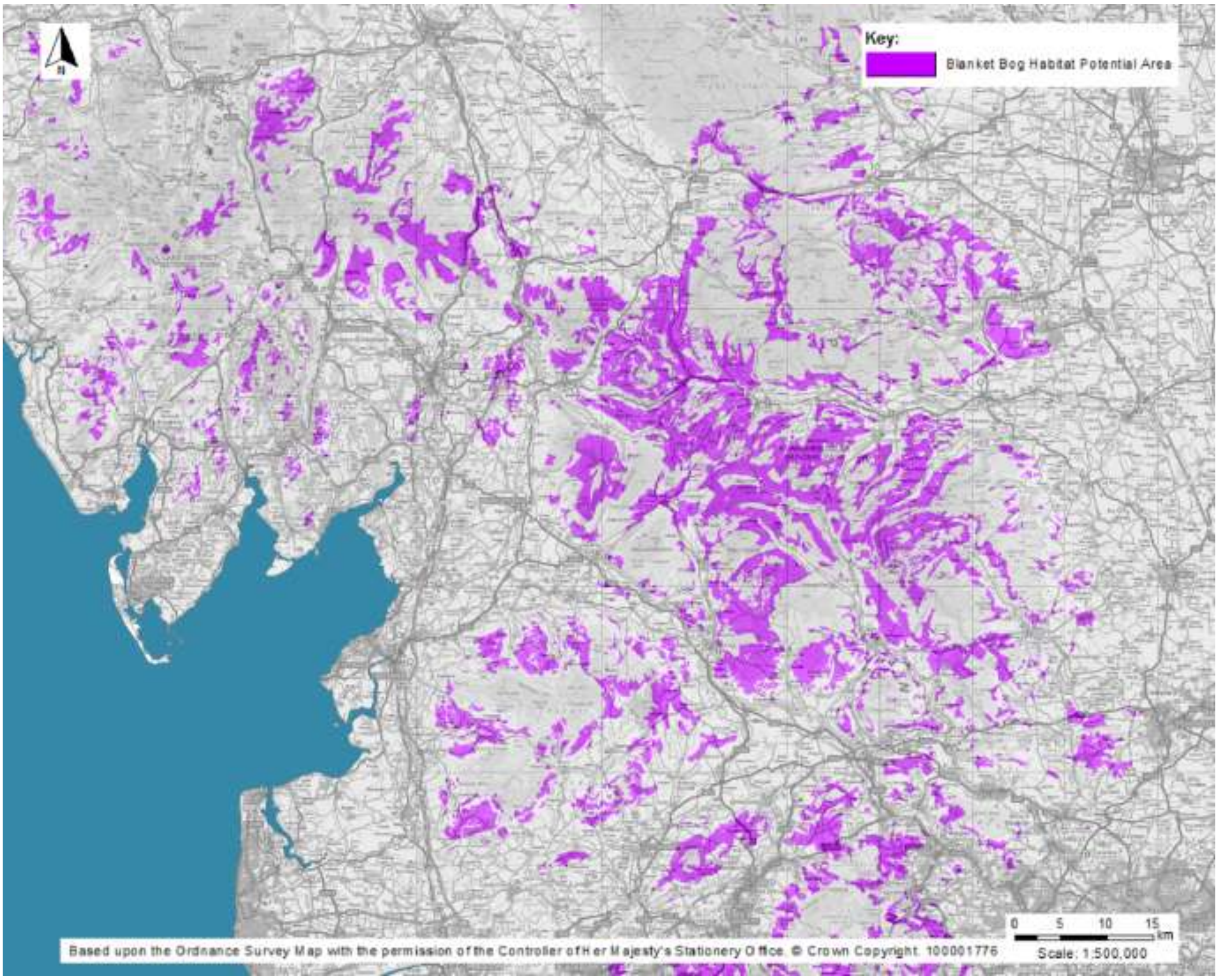


Plate 3.4 GIS Baseline Area of Potential Outputs – Blanket Bog

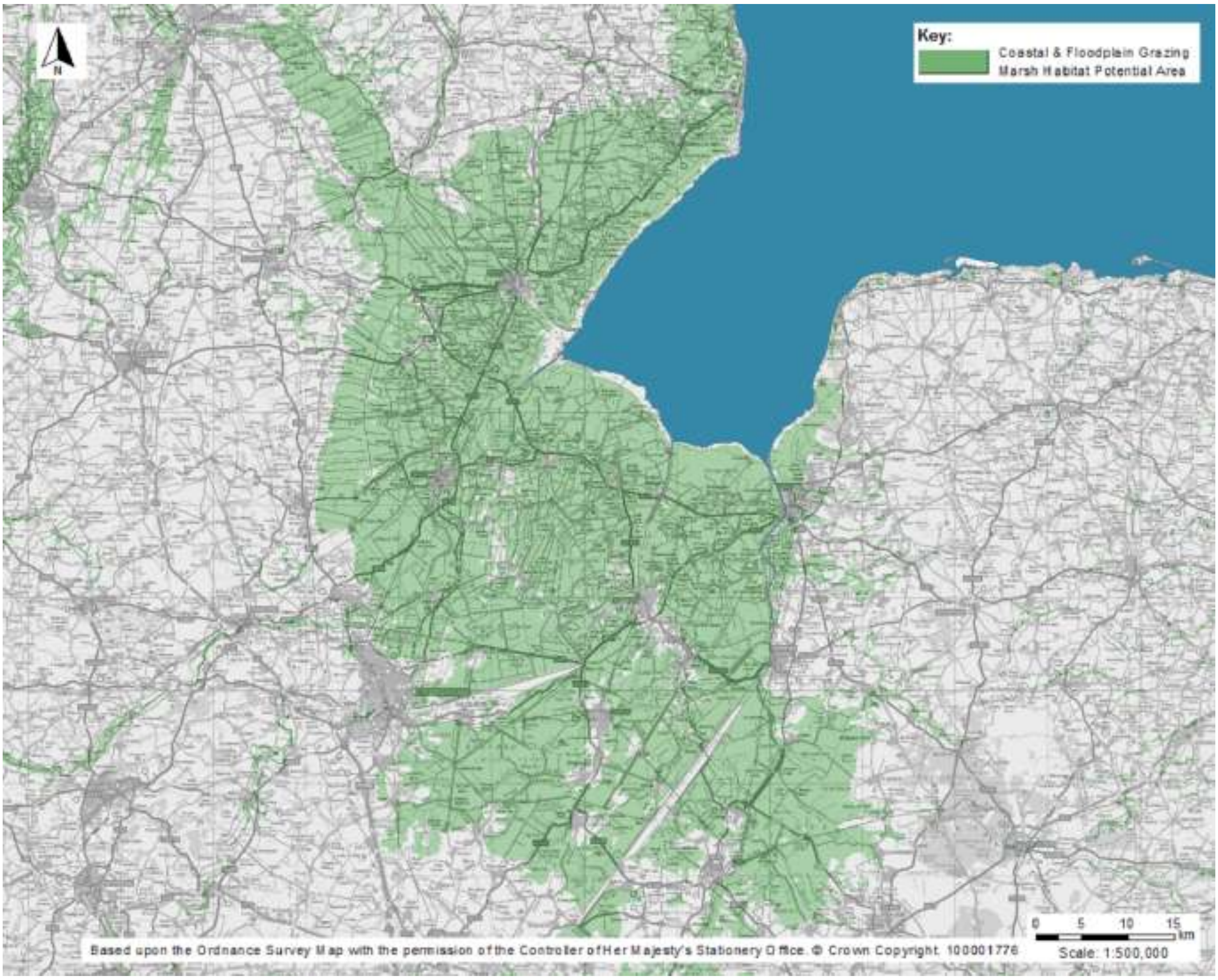


Plate 3.5 GIS Baseline Area of Potential Outputs – Coastal and Floodplain Grazing Marsh

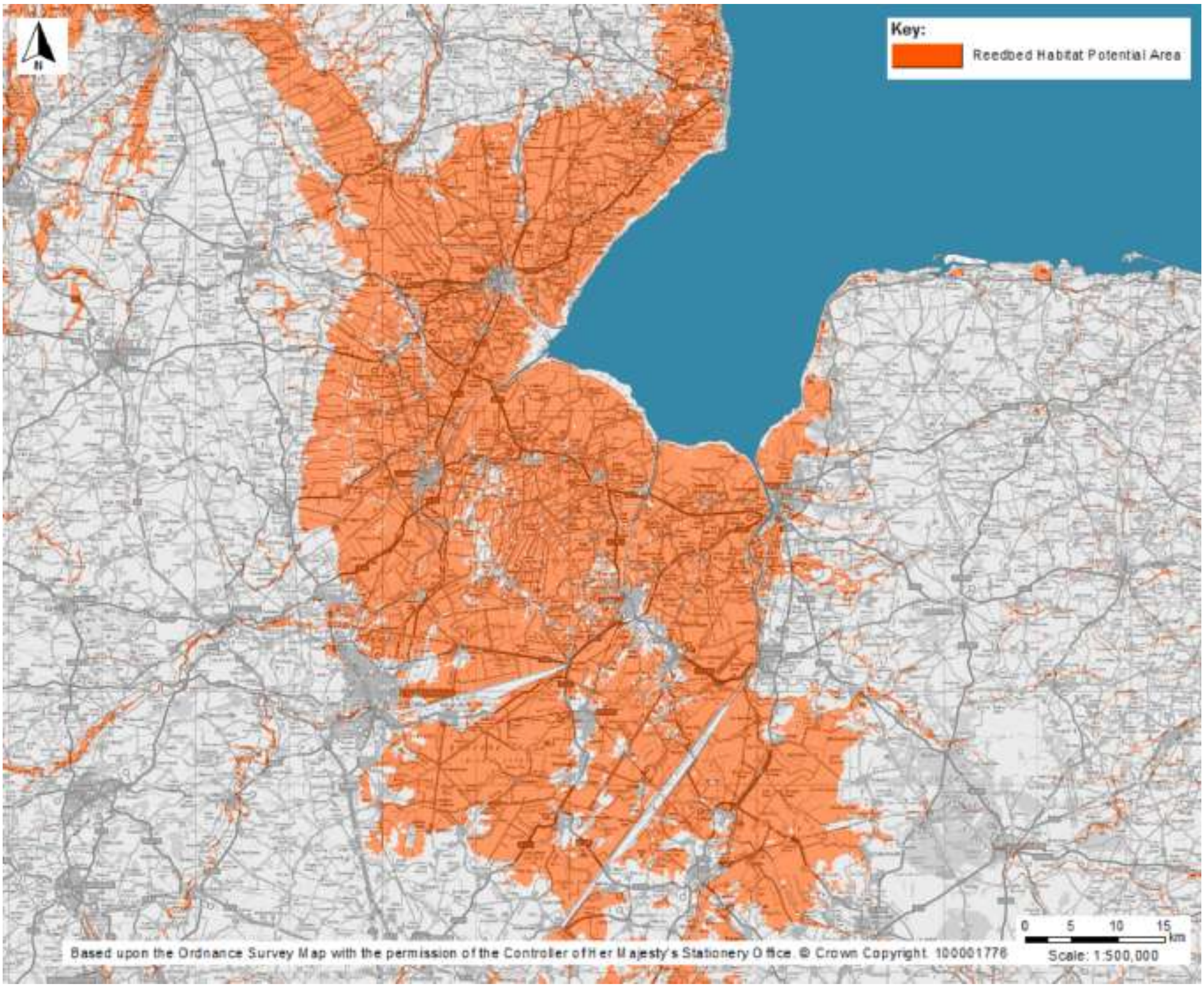


Plate 3.6 GIS Baseline Area of Potential Outputs - Reedbed

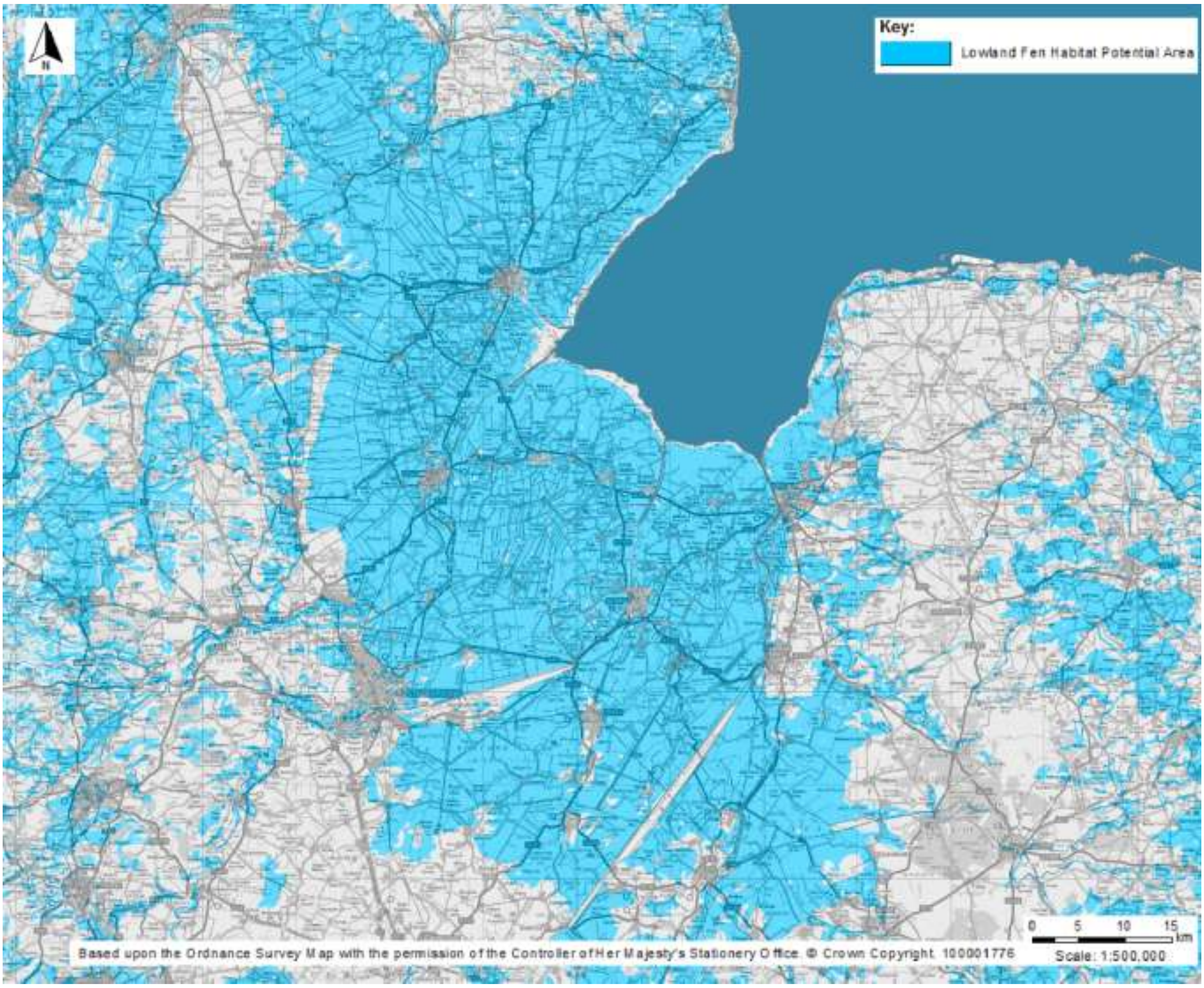


Plate 3.7 GIS Baseline Area of Potential Outputs - Fen

3.4 Extent of Areas with Potential for the Target Habitats

3.4.1 Baseline Areas of Habitat Potential

In adopting these environmental conditions for each priority habitat, it is evident that there are overlaps between some of the habitat potential areas. For example, both coastal & floodplain grazing marsh and reedbed have the same combination of conditions for certain suitable soils and also slope (see Table3.2).

To remove double counting of areas in the final outputs a decision was made to combine all target habitat potential land and apply the degraded habitat metric and weightings to this one single layer. This was achieved by using a series of ArcGIS geoprocessing tools (see Appendix B).

Table 3.4 summarises the areas, in hectares, of potential for each individual habitat. The total (with overlaps) for England was 5,120,679 ha. As a result of the GIS processing the combined habitat potential area was 3,621,802 ha. This represented a total overlap area of 1,498,877 ha. The combined habitat potential area equates to around 27.7% of the land area of England.

Table 3.4 Areas of Habitat Potential

Habitat Potential Areas	Area (ha)	% of England
Blanket Bog	346,989	2.66%
Coastal & Flood plain Grazing Marsh	878,652	6.74%
Coastal Sand Dune	5,161	0.04%
Coastal Vegetated Shingle	6,770	0.05%
Lowland Fen Base Poor Soligenous	249,803	1.92%
Lowland Fen Base Poor Topogenous	50,210	0.39%
Lowland Fen Base Rich Soligenous	1,074,709	8.24%
Lowland Fen Base Rich Topogenous	605,586	4.64%
Lowland Fen Variable Soligenous	411,289	3.14%
Lowland Fen Variable Topogenous	816,190	6.26%
Lowland Raised Bog	18,211	0.14%
Maritime Cliff and Slope	6,219	0.05%
Reedbed	649,272	4.98%
Saltmarsh	1,616	0.01%
Total (with overlaps)	**5,120,679**	**39.3%**
Total (without overlaps)	**3,621,802**	**27.7%**

The spatial distribution of the combined habitat potential area is shown below in Plate 3.8.

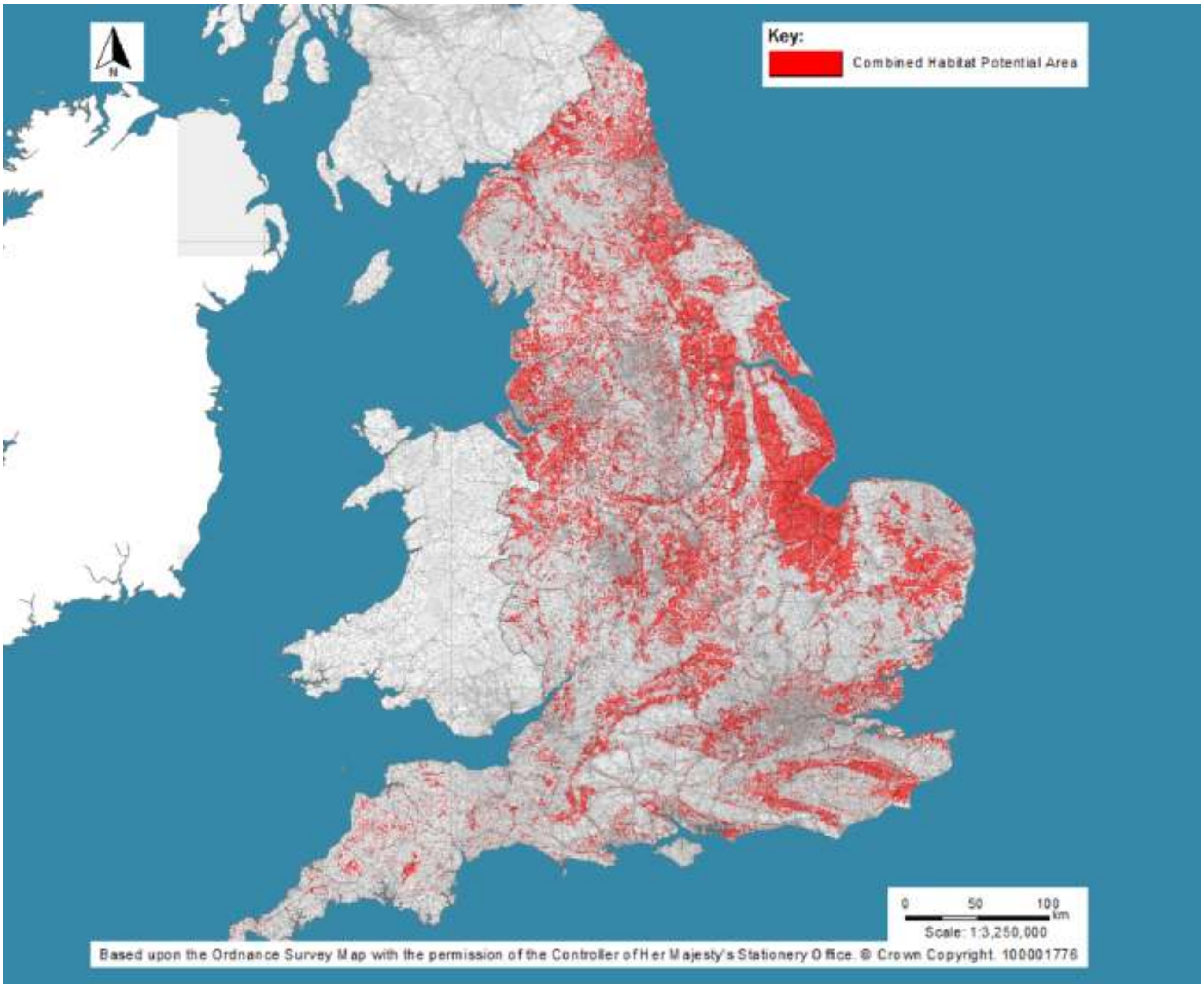


Plate 3.8 Spatial Distribution of Combined Habitat Potential Area

3.4.2 Comparison with Wetland Vision

The objective of the Wetland Vision project (Hume, 2008) was to produce a vision for freshwater wetlands in England, using maps and descriptive material agreed by all project partners, as a robust interpretation of what could be created or restored over the next 50 years. To secure the Wetland Vision a number of changes were identified as being necessary. These included significantly extending, and in some cases doubling, many lowland wetland habitats such as reedbed, ponds and grazing marsh. To this end the Wetland Vision maps highlight priority areas with potential for delivering these outcomes. The project delivered this by using GIS to develop a series of wetland habitat potential maps which, for each of the 10 habitats included, presented national distribution maps indicating a relative gradient from areas where suitable environmental conditions occur for a habitat, through to those areas that could offer the greatest opportunity for wetland delivery.

Given that the Wetland Vision project ran for three years and included consultation/ workshops with national wetland experts, the current project should have incorporated the Wetland Vision outputs. However, due to data licensing issues, this was not possible, although the Wetland Vision outputs were available for visual comparison.

This Outcome 1D project has used a broadly similar approach to the identification of areas with habitat potential as the Wetland Vision project in respect of matching soils and slope characteristics for all habitats, and clipping to the floodplain for certain habitats. As a result the habitat potential areas developed by the two projects therefore might have been expected to be the same and, by visual comparison, this is broadly the case for the majority of habitats. However, for fen there are some significant differences between the Outcome 1D and Wetland Vision fen potential maps. An example of the difference is that, when compared visually, it is particularly noticeable that in the Outcome 1D maps, the ‘solid’ Chalk aquifer geological formation that arcs south-westwards from the North Norfolk Coast to Hampshire and along the south coast of Sussex is not identified as having particular fen potential. Also, reference to the Lowland Fen BAP inventory contains very limited areas of fen in the same area. However the Wetland Vision maps identify the whole of this area as having at least baseline potential. The differences therefore merit some consideration.

The Wetland Vision has defined five categories of fen habitat as follows:

- Base rich groundwater fed fens;
- Base poor groundwater fed fens;
- Base poor fen in sumps and hollows;
- Floodplain and eutrophic fens; and
- Spring fed flush fen.

Although in general the Wetland Vision identified habitats by consideration of soil type and topography, as undertaken in this Outcome 1D project, it appears from Holliday (2008) that the approach adopted to identify potential fen habitat locations, notably for base rich groundwater fed fens and base poor groundwater fed fens, included additional steps and soils categories, not replicated in the 1D project. The additional steps principally include consideration of the presence and nature of aquifers, inclusion of locations/ areas where local soil types were known to support some of the fen types and to obtain additional guidance on map development for fens through a focus session attended by national fen experts.

In this respect it might be argued that the Wetland Vision depiction of fen potential areas is likely to be a more robust analysis of fen potential. However, it is worth noting that the Wetland Vision approach appears to take no specific account of depth to chalk (or the other aquifers) and hence identifies potential in some areas and on some soils that are perhaps unlikely to support the habitat. Additionally, the Wetland Vision identifies around 8.6 million ha of the 13 million ha of England (66%) as having potential for fen habitats which seems high.

By comparison with the Wetland Vision approach, the Outcome 1D fen habitat potential areas are most similar to, and used the most similar method, as the Wetland Vision floodplain and eutrophic fens category, albeit that for this project the baseline area of potential was not clipped to the floodplain extent as this would have excluded fens in more soligenous areas on higher ground. It is however considered that, for the purposes of this Outcome 1D project, the extent of floodplain and eutrophic fens, as depicted by the Wetland Vision project, is probably the most useful of the fen habitat types. This is because Outcome 1D has to be delivered over the next 8 years (compared to 50 years for the Wetland Vision) and, as a result, is most likely to target areas for fen restoration with readily available water sources (likely surface water) rather than seeking to develop a new/or restore a groundwater fed fen.

Notwithstanding the possible uncertainties with the Wetland Vision data outlined above, it was not possible to replicate or further develop, the Wetland Vision approach in the Outcome 1D project, in respect of groundwater fed fens in particular, because beyond the description presented in Holliday (2008) the precise steps and associations included in the Wetland Vision are not described in detail, nor are they available in the data that the Outcome 1D project team was supplied (which was also only supplied for reference, not analysis). Additionally, there were constraints on time and budget for the 1D project, relative to the Wetland Vision.

The implication of the differences in approach between the two projects however is that some potentially suitable areas for fen overlying aquifers are omitted from the Outcome 1D datasets. As a result some care will be needed in interpreting the outputs of the 1D project although, as indicated above, it is considered that the similarity between the fen potential areas developed in this project and those of the Wetland Vision floodplain and eutrophic fens category is the most useful in respect of the ability to create/restore habitat in the next 8 years.

To address the key differences between the two projects, particularly in respect of groundwater fed fens, consideration could be given to further development of the Outcome 1D model derived through this project to incorporate hydrogeological information. However, given the very large extent of fen potential habitat defined by the Wetland Vision, it is recommended that a similar but amended approach should be developed to ensure that potential for base rich groundwater fed fens and base poor groundwater fed fens are accounted for in the analysis, without over-representing the potential extent possible.

4. Areas of Degraded Target Habitat

4.1 Approach

The development of the final degraded target habitat layer for Outcome 1D also requires consideration of the extent of the nine habitat potential layers (as detailed in Section 3.4.1) which have been lost to other land use activities (e.g. arable farming) since the 1940 baseline date. These locations are referred to as "degraded target habitat" areas in the remainder of the report.

The identification of these areas has required the spatial comparison of two datasets. These are: (a) The Land Utilisation Survey Dudley Stamp maps (published by 1940) and (b) the Land Cover Map (LCM) 2007 dataset. The characteristics of these two datasets are described in detail below.

This stage and process is indicated in Plate 4.1 below.

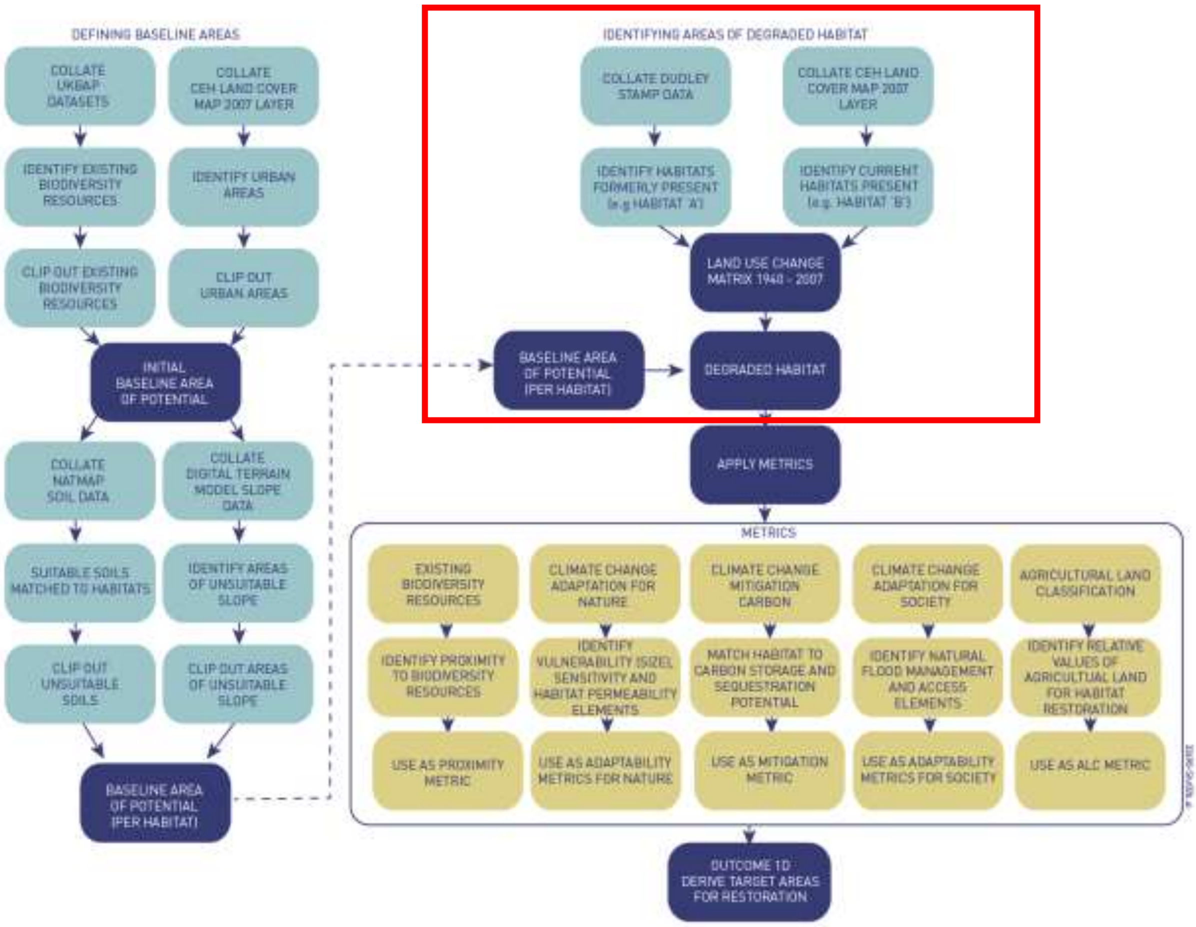


Plate 4.1 Flowchart Summarising the Process of Identifying Areas of Degraded Habitat

Land Utilisation Survey (LUS) - Dudley Stamp Maps

The 1940 baseline date used in the study, in part, reflects the availability of the first Land-Utilisation Survey (LUS) of Great Britain, directed by Professor L. Dudley Stamp. This survey created the first detailed record of the major land uses in England, Wales and southern Scotland and was published as a set of 169 map sheets. 135 of these maps covered England and Wales, using Ordnance Survey 1" maps as a base, and displaying land uses via a colour overlay.

In 2004, a project was funded by Defra to source, scan, geo-reference and disseminate the full set of the published LUS maps of Great Britain. However these maps were only available as scanned images and could not be used to undertake GIS based analysis of land use change.

To address this limitation of the data sources, AMEC was commissioned by the Environment Agency and Natural England to undertake a study to develop a method to systematically extract land-use information from the scanned LUS images. This method was used to classify a series of example map sheets across England and Wales and outputs were externally reviewed by the Environment Agency and Natural England. This quality assessment formally approved the method produced and led to final classification of the remaining images for England and Wales. An illustration of the output from the study is provided in Plate 4.2.

The final dataset is now published as a complete dataset via the Defra's MAGIC website (http://www.natureonthemap.naturalengland.org.uk/) which is administered by Natural England under a steering group.

Plate 4.2 Land-Utilisation Survey (LUS) Dudley Stamp – Illustration of the Translation Process

Land Cover Map 2007

The Land Cover Map 2007 (LCM2007) is produced by the Centre for Ecology & Hydrology and was released in 2011. Based on 2007 data, the dataset is derived from satellite images and digital cartography and presents land cover information for the entire UK. The LCM2007 dataset was produced from over seventy satellite images, which were combined into 34 multi-date summer-winter images. These images were classified using a variety of image processing technique and subjected to sampled quality review.

This processing resulted in the development of series of products, including the standard 25m raster product containing 23 land use classes, plus an accompanying vector parcel based products containing 10 detailed attributes. The 25m raster LCM 2007 product was used within this study.

The GIS processing steps used to relate the LUS Dudley Stamp and Land Cover 2007 dataset and develop the final degraded target habitat layer are described below.

4.2 GIS Processing

The LUS Dudley Stamp and LCM 2007 dataset have been used in combination to identify the areas of habitat potential which have been lost to alternative land uses since 1940. The GIS processing steps used to identify these areas are described below.

Creation of Dataset of Land Use Changes between 1940 and 2007

The first analysis step focused on the creation of a dataset of land use changes between 1940 and 2007. This was achieved by using ArcGIS-Spatial Analyst geoprocessing tools to create a spatial dataset showing all unique combinations between the LUS Dudley Stamp and LCM2007 datasets. A mask was also applied at this stage to only calculate land use changes within the 3.1million ha of land identified as having the potential to support priority habitats (see Section 3).

The processing resulted in the creation of a GIS layer with 192 different combinations of land use change. The attribute table of the overlay GIS grid was then reviewed by the AMEC team to categorise specific land use combinations into one of three categories shown below in Table 4.1.

Table 4.1 Key Land Use Change Combinations

Category	Description	Land Use Combination - Example		Comment
		Dudley Stamp	Land Cover Map 2007	
Different	Area of non target land lost to alternative land use not directly relevant to the aims of the study or Area of target land that is now another habitat that is potentially of conservation value – whether this is a target for this study or not	Woodland Heath and moorland	Acid grassland Broad-leaved, mixed and yew woodland	Category not relevant to definition of final degraded habitat layer
Lost	Potential area of target habitat which has been lost to alternative land use not of conservation value	Heath/Moorland	Arable	Category relevant to definition of final degraded habitat layer
Same	No change in land use type between 1940 and 2007	Arable	Arable	Category not relevant to definition of final degraded habitat layer

Using this system, each of the 192 unique land use change classes were assigned to one of three categories. A full list of the combinations is provided in Appendix B.

Identify Target Areas of Land Lost between 1940 and 2007

An ArcGIS Spatial Analyst reclass operation was then used to group each of land use change categories into one of 18 simplified land use categories for further consideration and assessment (see Table 4.2).

Table 4.2 Key Land Use Change Combinations

Dudley Stamp Class	Status	Area (ha)	% of Total	% of England
Unclassified		178,626	4.93%	1.37%
Heath and Moorland	**Lost**	**93,057**	2.57%	**0.71%**
Heath and Moorland	Different	159,873	4.42%	1.23%
Heath and Moorland	Same	85,904	2.37%	0.66%
Water	Lost	56,509	1.56%	0.43%
Water	Different	11,724	0.32%	0.09%
Water	Same	4,448	0.12%	0.03%
Arable	Lost	12,334	0.34%	0.09%
Arable	Different	53,645	1.48%	0.41%
Arable	Same	1,014,405	28.02%	7.78%
Meadow and Grass	**Lost**	**928,708**	25.65%	**7.12%**
Meadow and Grass	Different	65,256	1.80%	0.50%
Meadow and Grass	Same	831,555	22.97%	6.38%
Forest and Woodland	Lost	58,643	1.62%	0.45%
Forest and Woodland	Different	40,781	1.13%	0.31%
Forest and Woodland	Same	9,417	0.26%	0.07%
Orchard	**Lost**	**14,409**	0.40%	**0.11%**
Orchard	Different	993	0.03%	0.01%
Orchard	Same	-	0.00%	0.00%
Total		**3,620,287**	**100.00%**	**27.76%**
Heath/Moorland, Meadow/Grass and Orchard		**1,036,175**	**28.6%**	

Table Note: Orchards have been included at this stage because it is one of the habitats specifically mapped in the Dudley Stamp data and for which there is a current BAP inventory. Orchards were not one of the original target habitats for the project.

Three of the combinations are particularly relevant to the outcomes of this study. These are:

- Heath and Moorland lost to other non permanent development, not likely to be of nature conservation value;
- Meadow and Grass lost to other non permanent development, not likely to be of nature conservation value; and
- Orchard lost to other non permanent development, not likely to be of nature conservation value.

Although it is possible that the ‘water’ class of the Dudley Stamp data would have included habitat that might be classed as fen, the ‘water’ class has been omitted from the calculations of land use change because many water features are linear and significant errors are likely when comparing the 1940s data with recent Land Cover data. The significant uncertainties associated with this have resulted in this class being omitted.

The Dudley Stamp 'forest and woodland' class has not been included as Natural England will refer to Forestry Commission data to establish where woodlands are to be created and how this will contribute to Outcome 1D.

The areas of changed land use were then compared with the baseline areas of habitat potential. Only those areas of changed land use that coincide with areas of habitat potential have been taken forward as it has been assumed that if they coincide with areas of potential that they could have been the target habitats in the 1940s or previously.

The total extent of three classes outlined above equate to about 1,036,175 ha or about 8% of the total geographical size of England. The spatial distribution of these key categories is shown below in Plate 4.3.

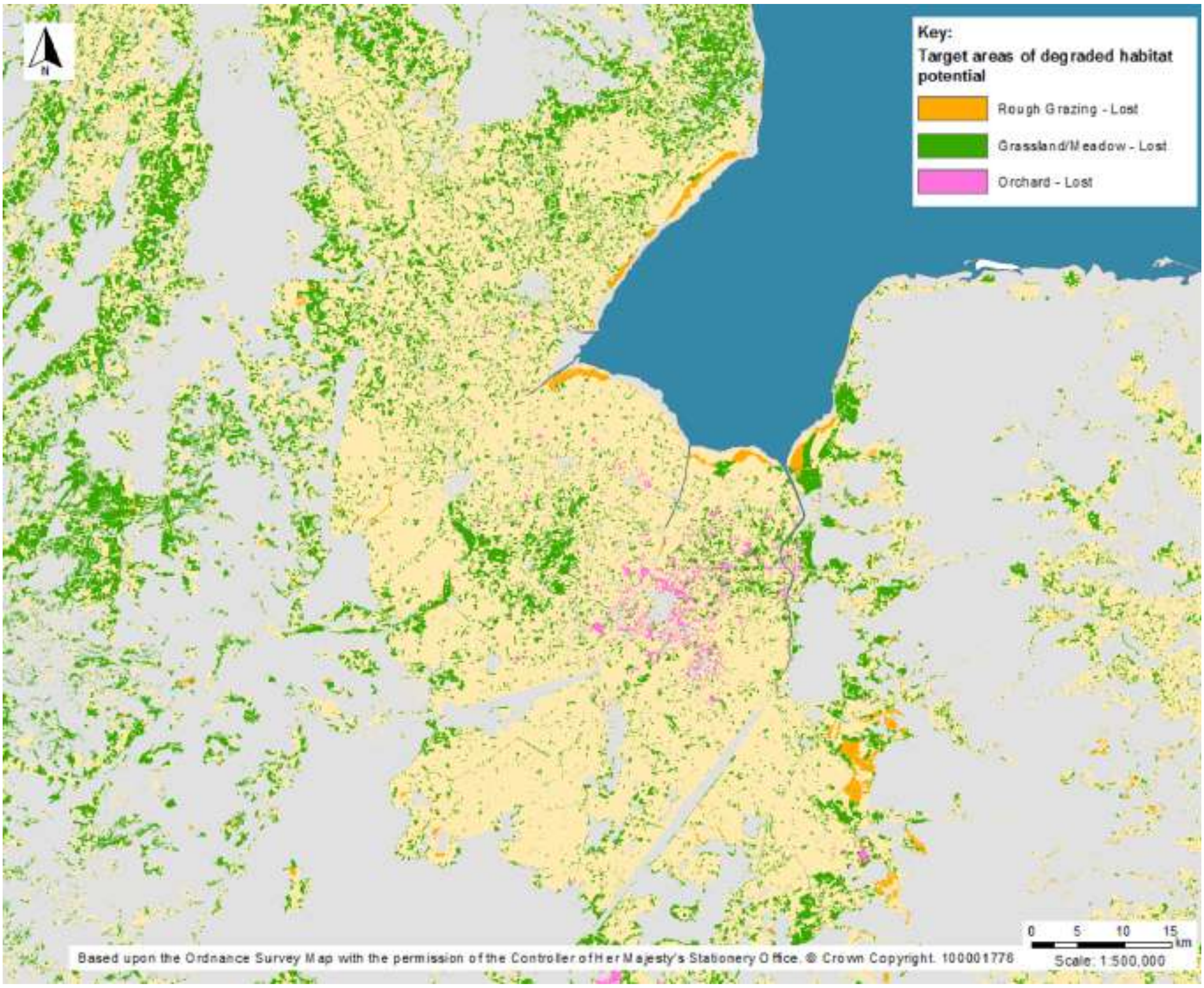


Plate 4.3 Target Areas of Degraded Habitat Potential

In viewing these final land use combinations, it is important to remember that there are inherent limitations (in terms of resolution and classification accuracy) of both the Dudley Stamp and Land Cover 2007 land use datasets used in this assessment. To reduce the impact of these issues upon the final outputs, and because it was agreed with the project board that areas of degraded habitat of 1ha in size or less were unlikely to be targeted for restoration action, a decision was made to remove all potential areas of target habitat potential land which were less than 1ha in size.

This was achieved by using a series of ArcGIS geoprocessing tools as shown in Plate 4.4.

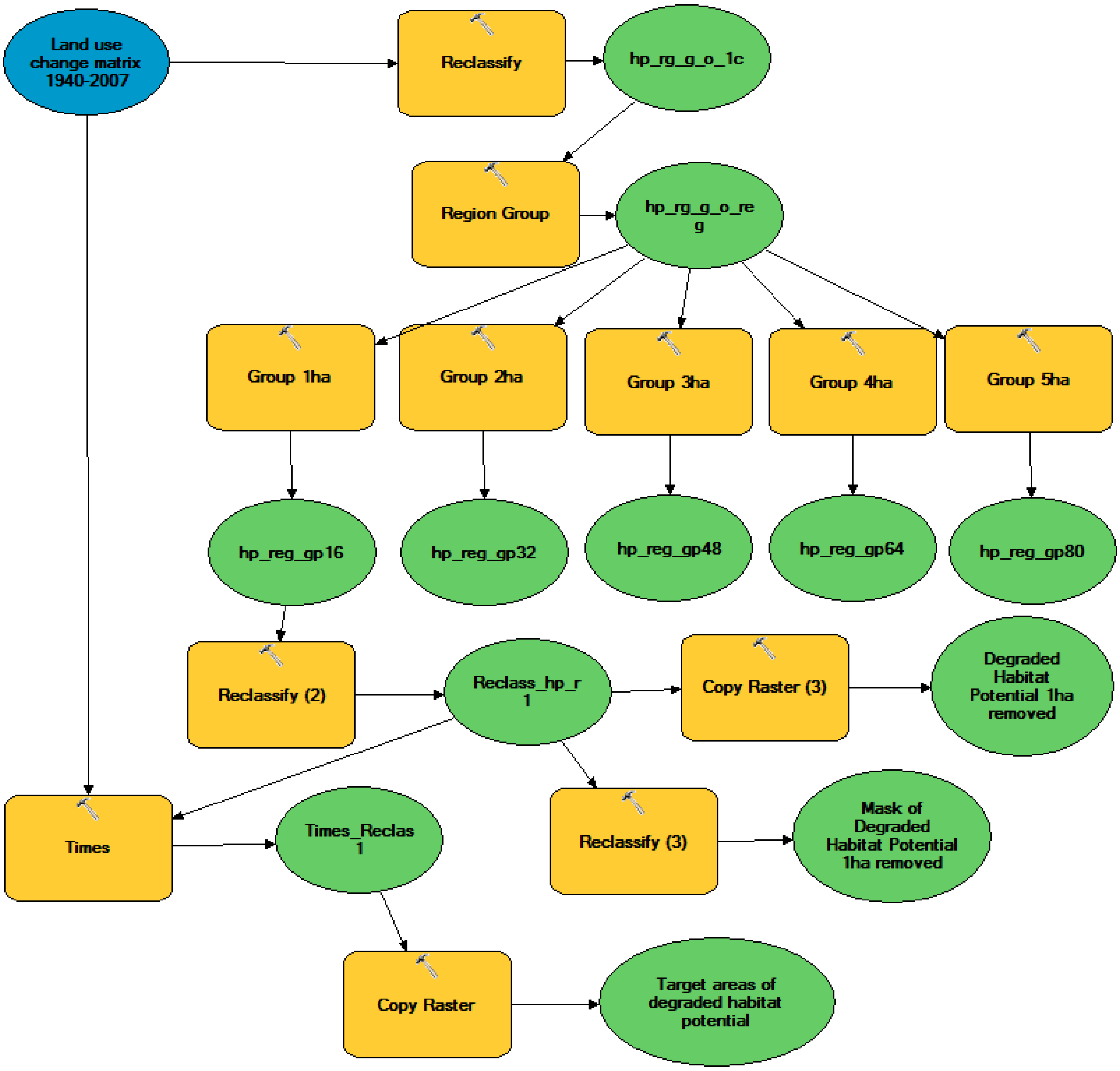


Plate 4.4 Model to Remove Target Habitat Potential Area Smaller than 1ha in Size

The impact of removing the plots of land of less than 1ha is outlined below in Table 4.3.

Table 4.3 Final Degraded Habitat Layer – Area and % Statistics

	Total Area (ha)	Total Area - % Removed	% of England	Outcome 1D 15% Target (ha)
Habitat Restoration Target - Heath/ Moorland plus Meadow/Grass – Degraded Habitat	1,036,175		7.95	155,426
Habitat Restoration Target - Heath/ Moorland plus Meadow/Grass - Plots exceeding 1ha only	947,484	8.56	7.27	142,122
Heath and Moorland	82,058	11.82	0.63	12,309
Meadow and Grassland	852,332	8.22	6.54	127,850
Orchard	13,094	9.13	0.10	1,964

Table Note: orchard included only where it coincides with other areas of habitat potential.

The final target layer of degraded habitat included 947,484 ha of potential land with an indicative estimate of 15% target equating to about 142,122 ha. These equate to around 7.3% and 1.1% of the land area of England respectively.

The final layer of target habitat potential is shown below in Plate 4.5.

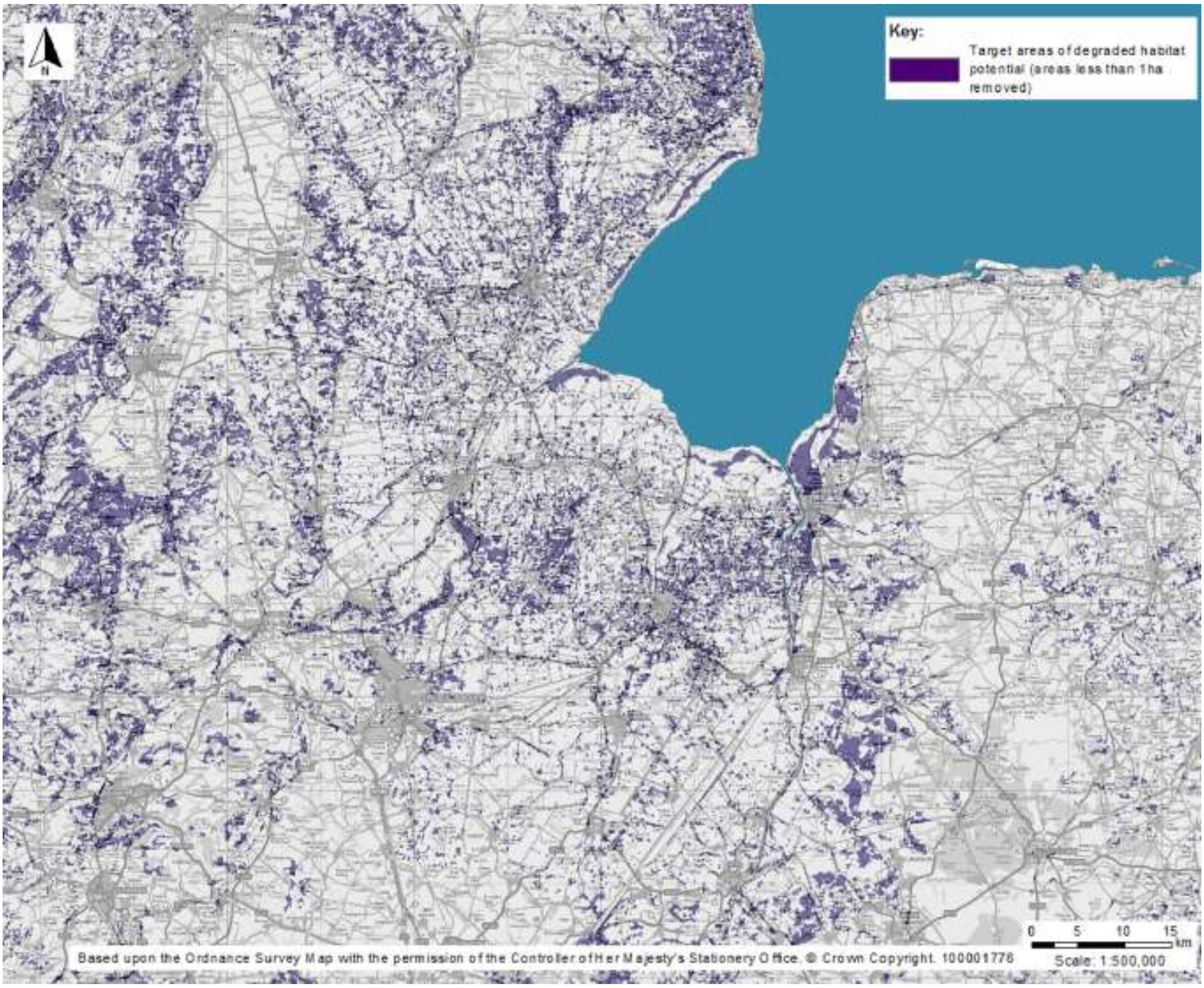


Plate 4.5 Target Areas of Degraded Habitat Potential (Areas of Less than 1ha Removed)

5. Prioritising Areas of Degraded Habitat for Restoration

5.1 Approach

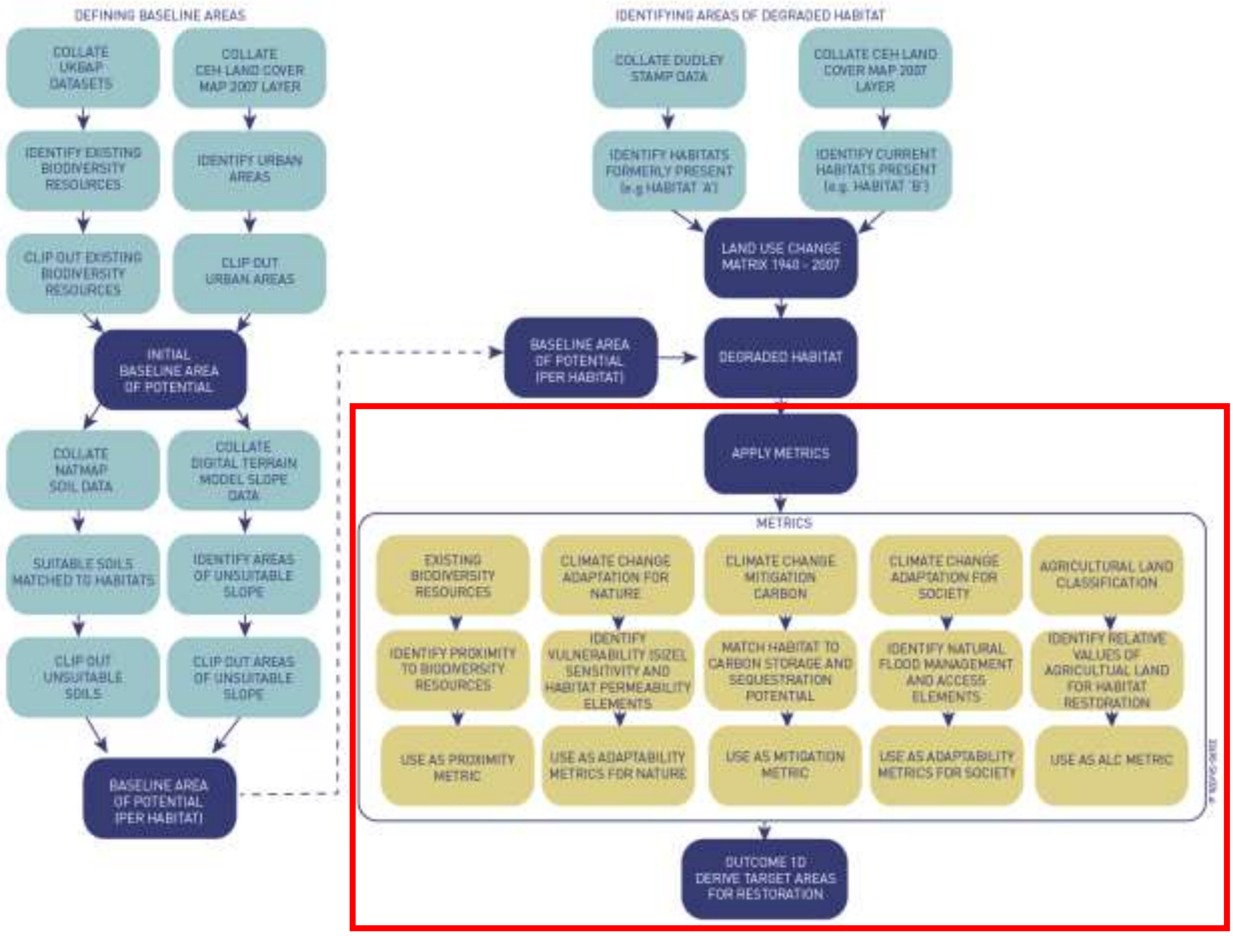
The final target layer of degraded habitat included 947,484 ha of potential land with an Outcome 1D restoration estimate of 15% equating to about 142,122 ha. However, it is not sufficient to know that a 15% restoration target equates to 142,122 ha. There is clearly a need to target which areas would be best suited to restoration efforts. There are a number of possible drivers that could be used to target restoration efforts but the key considerations include:

- Proximity to existing biodiversity resources;
- Ability of the target habitats to mitigate climate change though carbon storage and/or sequestration;
- Ability of the target habitats to adapt to climate change (adaptation for nature);
- Ability of target habitats to adapt to climate change to provide benefits in respect of natural flood management and/or to society; and
- The relative agricultural (which translates to monetary) value of the land likely to be targeted for restoration.

If the project or approach was developed further it might be possible to assess the value of the habitats in respect of wider ecosystem services, in addition to those implicitly covered by the considerations above e.g. provisioning or supporting services.

The process of identifying target areas best suited to restoration efforts has been undertaken by defining and applying a series of metrics to the degraded habitat areas. This stage and process is indicated in Plate 5.1 below.

Plate 5.1 Flowchart Summarising the Process of Defining and Applying Metrics



5.2 Metrics

Six metrics have been identified and applied to the degraded habitat extents. The metrics and the rationale supporting their development is presented in the following sections.

5.2.1 Proximity to Biodiversity

Proximity to existing biodiversity resources is an important consideration when deciding where to restore/create habitat of nature conservation value. Ideally an area of new/ restored habitat would be created immediately adjacent to an area of existing habitat resource of nature conservation value as the shorter the distance between two blocks of habitat the easier it is for species to move between them. Additionally it is easier to protect and manage contiguous areas of habitat.

This metric has therefore been define such that the shortest distance between an area of degraded habitat and an existing biodiversity resource scores highest. The metric is presented in Table 5.1 below.

In this metric the highest score is attributed to those areas closest to a designated site or a UK BAP habitat.

Table 5.1 Proximity to Biodiversity Metric

Distance to Designated Sites (m)	Score	Distance to existing UKBAP Biodiversity Resources (m)	Score	Metric	Score
0-100	5	0-100	5	**Nearest to designated site or BAP habitat**	**5**
101-250	4	101-250	4		**4**
250-500	3	250 - 500	3		**3**
501-1000	2	501 - 1000	2		**2**
>1000	1	>1000	1	**Furthest from designated site and BAP habitat**	**1**

5.2.2 Climate Change (Carbon) Mitigation

The potential for habitats to mitigate climate change is an important consideration in respect of future habitat restoration/creation.

Two elements have been considered in this context: carbon storage and carbon sequestration. There are a number of published sources of carbon storage and sequestration data but none covers all the target habitats included in this study and interpretation/comparison of the results is not always straightforward because of the different units discussed. Additionally, more often the data are quoted based on the substrate rather than the habitat. Nonetheless, an attempt has been made to rank the value of the target habitats for carbon storage and sequestration to inform this metric.

Carbon Storage

The key references used to inform the ranking of the target habitats in respect of their carbon storage abilities are:

- Alonso, I., Weston, K., Gregg, R. & Morecroft, M. (2012). Carbon storage by habitat - Review of the evidence of the impacts of management decisions and condition on carbon stores and sources. *Natural England Research Reports, Number NERR043;* and
- Natural England (2010). England's peatlands – carbon storage and greenhouse gases. Natural England Research Report 257.

Reference has also been made to the publications below although these did not yield useful data for this metric.

- Worrall, F., Chapman, P., Holden, J., Evans, C., Artz, R., Smith, P. & Grayson, R. (2011). A review of current evidence on carbon fluxes and greenhouse gas emissions from UK peatland. *JNCC Report*, No. 442.
- Milne, R. and Brown, T.A. (1997). Carbon in the vegetation and soils of great Britain. *Journal of Environmental Management* (1997) **49**, 413–433.
- University of Hertfordshire (2011). *A revisit to previous research into the current and potential climate change mitigation effects of environmental stewardship* (BD5007).

Data derived from these sources for the target habitats are presented as carbon storage in tonnes/C/ha and are presented in Table 5.2 below along with the sub-metric score assigned. The score has been assigned simply with the habitats having the highest carbon storage potential given the highest score with other scores grading down to the habitats with the lowest potential.

Table 5.2 Carbon Storage Values

Carbon Storage	C Storage Values from NERR043 (t C ha)	C Storage Values from NE 2010 (t C ha)	Sub-Metric Score
Coastal saltmarsh	48		1
Coastal sand dunes	48		2
Coastal vegetated shingle	Expected low		1
Maritime cliffs and slopes	Expected low		1
Coastal and floodplain grazing marsh	60		3
Blanket bog	74	388	4
Lowland Fen	76	1503	5
Lowland raised bog	74	1610	5
Reedbed	76	1503	5

It should be noted that the carbon storage figures taken from NERR043 are estimates based on the top 15cm of soil only. The NE 2010 figures are for deep peat areas.

The NE2010 carbon storage figures have been derived by dividing the quoted estimated total carbon stored in England's deep and shallow peaty soils by the estimated extent of the habitats. It is noted that the estimated total carbon quoted in NE, 2010 is that stored in England's deep and shallow peaty soils whilst the estimated extent of habitats used in the calculation is that located on deep peat. If data were available for the distribution of the habitats on shallow peat soils also, the carbon storage value for blanket bog would probably remain unaltered as the definition of deep peat used in NE, 2010 is that areas are covered with a majority of peat >40cm deep. It is possible that the figures for lowland fen, reedbed and lowland raised bog would be reduced if the inclusion of these areas increased the quoted extent of the habitat nationally but, given that the extent of the shallow peat soils is quoted as being 5,272km^2, i.e. about 1500km^2 less than the area of deep peat, it is not believed that this would result in much if any change in the rankings used in the metric.

Carbon Sequestration

The key references used to inform the ranking of the target habitats in respect of their carbon sequestration abilities are the same as those presented above plus:

- Natural England (2012). Environmental Stewardship and Climate Change Mitigation. NE TIN109.

Data derived from these sources for the target habitats are presented as carbon sequestration in tonnes/C/ha/y and are presented in Table 5.3 below along with the sub-metric score assigned. The score has been assigned simply with the habitats having the highest carbon sequestration potential given the highest score with other scores grading down to the habitats with the lowest potential.

Table 5.3 Carbon Sequestration Values

Carbon Storage	C Sequestration Values from NERR043 (T C ha yr-1)	C Sequestration Values from NE (2012) (T C ha yr-1)	Sub-Metric Score
Coastal saltmarsh	2.1		**5**
Coastal sand dunes	0.65		**3**
Coastal vegetated shingle	Expected low		**1**
Maritime cliffs and slopes	Expected low		**1**
Coastal and floodplain grazing marsh	Net emitter to low sequester?		**1**
Blanket bog	0.46	2.7*	**5**
Lowland Fen	0.46	0.25	**2**
Lowland raised bog	0.46	2.7*	**5**
Reedbed	0.46	1.09	**4**

* Figure relates to restoration of moorland

Metric

The metric is presented in Table 5.4 below.

Table 5.4 Climate Change (Carbon) Mitigation

Carbon Storage	Carbon Storage Score	Carbon Sequestration Score	Overall Metric Score
Coastal saltmarsh	1	5	3
Coastal sand dunes	2	3	3
Coastal vegetated shingle	1	1	1
Maritime cliffs and slopes	1	1	1
Coastal and floodplain grazing marsh	3	1	2
Blanket bog	4	5	5
Lowland Fen	5	2	4
Lowland raised bog	5	5	5
Reedbed	5	4	5

No data on the carbon characteristics of orchard were located during the analysis.

The overall metric score is calculated as the average of the two sub-scores rounded up for ease of processing within GIS.

5.2.3 Climate Change Adaptation for Nature (Vulnerability)

The potential for habitats to be able to adapt to climate change is an important consideration in respect of future habitat restoration/creation.

A national biodiversity climate change vulnerability model has been developed by Taylor and Knight (2013, draft report). The Natural England project has derived a series of metrics to address a number of factors including habitat sensitivity, habitat fragmentation, topographic heterogeneity, habitat condition and conservation value. These metrics have then been applied to the existing BAP inventories to rank their vulnerability to climate change.

It was not possible to use the outputs of this model directly within this Outcome 1D project because the Outcome 1D project clipped out the existing BAP inventories from the analysis to prevent also identifying them as potential habitat areas. However some of the principles have been adopted to derive a climate change adaptation for nature (vulnerability) metric.

For the purposes of this project the four elements are considered important in influencing the ability of areas of habitat to adapt to climate change. These are: fragmentation, sensitivity to climate change, habitat permeability and nearby land cover. Further information is provided on these elements below.

Habitat Fragmentation

It is an accepted principle that the larger an area of habitat is, the more resilient they will be change because larger habitat patches support larger populations which are more resilient to extinction during extreme climatic events such as droughts and floods. They can also accommodate a wider range of soil types and topographical variations in microclimate, increasing the probability of species being able to persist in localised pockets of suitable conditions.

This principle is reflected in the Climate change adaptation for nature (vulnerability) metric through allocating a higher score to larger habitats blocks (Table 5.7). A decision was taken to assign a different scale to the inland and coastal habitats because areas of coastal habitat will be more constrained by their location and as a result it seemed appropriate all reduce the habitat areas required to achieve the highest score.

The size categories themselves however are fairly arbitrary.

Sensitivity to Climate Change

Taylor and Knight (2013, draft report) ranked the sensitivity of habitats to climate change. This ranking has been used directly in the climate change adaptation for nature (vulnerability) metric. The sensitivities are presented in Table 5.5 below and the scores for the metric are presented in Table 5.7.

Table 5.5 Habitat Sensitivity

High Sensitivity	Medium Sensitivity	Low Sensitivity
Coastal and floodplain grazing marsh Coastal saltmarsh Lowland raised bog Maritime cliff and slope	Coastal vegetated shingle Reedbeds Blanket bog Lowland fen Coastal sand dunes	No habitats in this study

Habitat Permeability (BAP Habitats and Land Cover)

Habitat permeability has been assessed in the context of whether areas of degraded habitat touch or are distant from similar habitats. Two measures of habitat permeability have been included, one related to BAP habitats and one related land cover habitat types.

In respect of the BAP habitat, if an area of degraded habitat touches (or is within 100m to allow for margin of error in the GIS) an area of target BAP habitat (i.e. one of the habitats that is included in this Outcome 1D project, then it achieves the maximum score. If however it touches an area of non-target

BAP habitat it achieves an intermediate score and if it does not touch BAP habitat it achieves the lowest score.

In respect of land cover types, habitat categories have been assigned as semi-natural, neutral and non-target land cover types as indicated in Table 5.6 below. The habitats have been allocated to different categories depending on whether it is an inland or coastal habitat that is being considered.

Table 5.6 Land Cover Habitat Allocations

	Inland Habitat Matches	
Semi-natural	**Neutral**	**Non-target**
Broadleaved, mixed and yew woodland Rough grassland Neutral grassland Calcareous grassland Acid grassland Fen, marsh and swamp Heather Heather grassland Bog Montane habitats Freshwater	Saltwater Supralittoral rock Supralittoral sediment Littoral rock Littoral sediment Saltmarsh	Unclassified Coniferous woodland Arable and horticulture Improved grassland Inland rock Urban Suburban
	Coastal Habitat Matches	
Semi-natural	**Neutral**	**Non-target**
Saltwater Supralittoral rock Supralittoral sediment Littoral rock Littoral sediment Saltmarsh	Broadleaved, mixed and yew woodland Rough grassland Neutral grassland Calcareous grassland Acid grassland Fen, marsh and swamp Heather Heather grassland Bog Freshwater	Unclassified Coniferous woodland Arable and horticulture Improved grassland Inland rock Urban Suburban Montane habitats

Metric

The metric elements are presented in Table 5.7 and the overall metric in Table 5.8 below.

Table 5.7 Climate Change Adaptation for Nature Metric Elements

Fragmentation	Size (ha) of Outcome 1D polygon for inland habitats only	Size (ha) of Outcome 1D polygon for supra-littoral habitats only	Sub-score	Sensitivity to climate change (potential habitat areas)	Sub-score	Habitat Permeability (BAP habitat)	Sub-score	Habitat Permeability (Land Cover)	Sub-score
Low	>500	>75	5	Low	**5**	Touching (within 100m to allow for margin of error) target BAP habitat (from existing inventories)	**5**	Touching (within 100m to allow for margin of error) semi-natural inland habitat	**5**
	100-500	50-75	4						
Medium	50-10	25-50	3	Medium	**3**	Touching (within 100m to allow for margin of error) non-target BAP habitat (from existing inventories)	**3**	Touching (within 100m to allow for margin of error) Neutral habitats	**3**
	10 - 50	10 -25	2						
High	<10	<10	1	High	**1**	Not touching BAP habitat	**1**	Touching (within 100m to allow for margin of error) arable or improved grassland or similar	**1**

Table 5.8 Climate Change Adaptation for Nature Overall Metric

Overall Metric	Range of Sub-scores	Metric Score
Least vulnerable and sensitive	17-20	**5**
	13-16	**4**
	9-12	**3**
	5-8	**2**
Most vulnerable and sensitive	1-4	**1**

5.2.4 Climate Change Adaptation for Society (Flood Risk)

It is accepted that, when located in a floodplain, wetlands can act to reduce the risk of flooding by attenuating run-off from surrounding land or river flows. This metric tries to capture this potential benefit by assigning a higher score to areas of degraded habitat located within flood zones.

It is accepted that not all the target habitat are wetlands (e.g. orchard) and so the principle does not apply well to all habitats however the non-wetland target habitats are probably still of greater value in terms of run-off attenuation than arable or improved grassland for example. Additionally, the non-wetland habitats are represented by low areas in the analysis and as a result it is considered unlikely to make much difference to the overall analysis.

The metric is presented in Table 5.9 below.

Table 5.9 Climate Change Adaptation for Society (Flood Risk) Metric

Climate Change Adaptation for Society (Flood Risk)	Score
Potential habitat within 1 in 100 flood zone (flood zone 3)	5
Potential habitat within 1 in 1000 flood zone (flood zone 2)	3
Potential habitat within flood zone 1 i.e. Less than 1:1000 chance of flooding	1

5.2.5 Climate Change Adaptation for Society (Access)

It is accepted that visiting the countryside can increase people's feeling of well-being. There are numerous areas of the country that have landscape designations and which are targeted as tourist destinations (e.g. Areas of Outstanding Natural Beauty, National Parks etc.). It is however possible that additional value could be added to areas outside this existing network of landscape designations and tourist destinations if habitat of nature conservation value was created in these areas, with the proviso that this would be accessible to local people.

The rationale for this metric is therefore that habitat creation in areas more accessible for people, i.e. within a certain distance of larger urban areas, but not within areas already the focus of tourism would be preferable (and hence score higher).

The metric is presented in Table 5.10 below.

Table 5.10 Climate Change Adaptation for Society (Access) Metric

Climate Change Adaptation for Society (Access)	Score
Potential habitat within 5 km of larger urban areas and not within AONB or National Park or open access land or registered battlefields or historic parks and gardens or biosphere reserves	5
Potential habitat more than 5km of larger urban areas use and not within AONB or National Park or open access land or registered battlefields or historic parks and gardens or biosphere reserves	3
Potential habitat within AONB or National Park or open access land or registered battlefields or historic parks and gardens or biosphere reserves	1

5.2.6 Agricultural Land Classification

Not all agricultural land has the same productivity or monetary value. Areas of grade 1, 2 and 3a agricultural land are deemed to be the best and most versatile areas. There is therefore likely to be an increased cost, and increased implication in respect of food production if grade 1, 2 and 3a agricultural land are targeted for habitat restoration/creation. The metric is presented in Table 5.11 below.

Table 5.11 Agricultural Land Classification Metric

Agricultural Soils Class	Score
5	5
4	5
3	3
2	1
1	1

This metric gives the lowest score to the most productive and valuable agricultural land as defined by the agricultural land classification. It is not possible to split agricultural land class 3a and 3b from the datasets available and hence grade 3 land has been assigned a metric score of 3 rather than 5.

5.3 GIS Processing

The decision rules for each of metrics were transferred into a series of ArcGIS geoprocessing models. An example for the proximity to biodiversity metric is provided below in Plate 5.2, with further models presented in Appendix C.

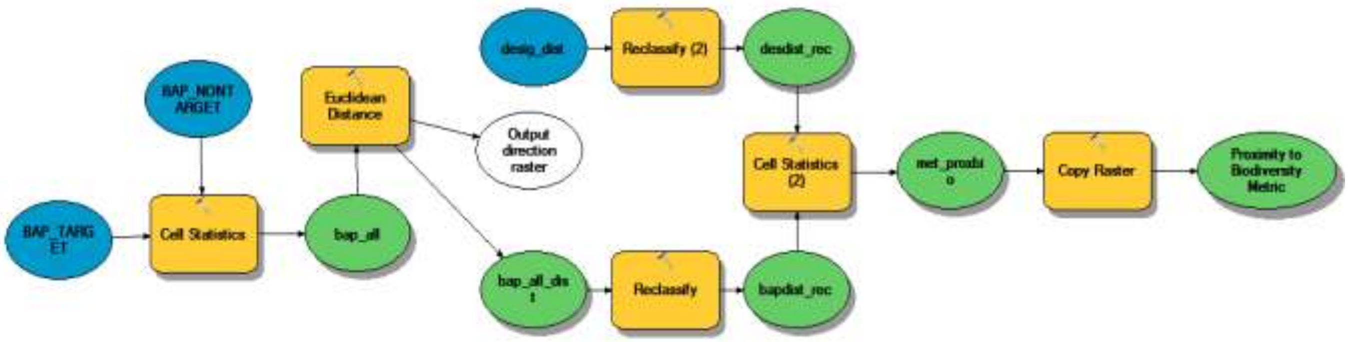


Plate 5.2 Geoprocessing Model for the Proximity to Biodiversity Metric

Using these models, ArcGIS was used to prepare a series of GIS layers indicating the relative suitability for restoration (on a scale of 1-5) for the following factors:

- Proximity to existing biodiversity;
- Climate change (carbon) mitigation;
- Climate change adaptation for nature;
- Climate change adaptation for society (flood risk);
- Climate change adaptation for society (access);
- Agricultural land classification.

Examples of the outputs for these metrics for an area of Eastern England are provided below in Plates 5.3 to 5.13.

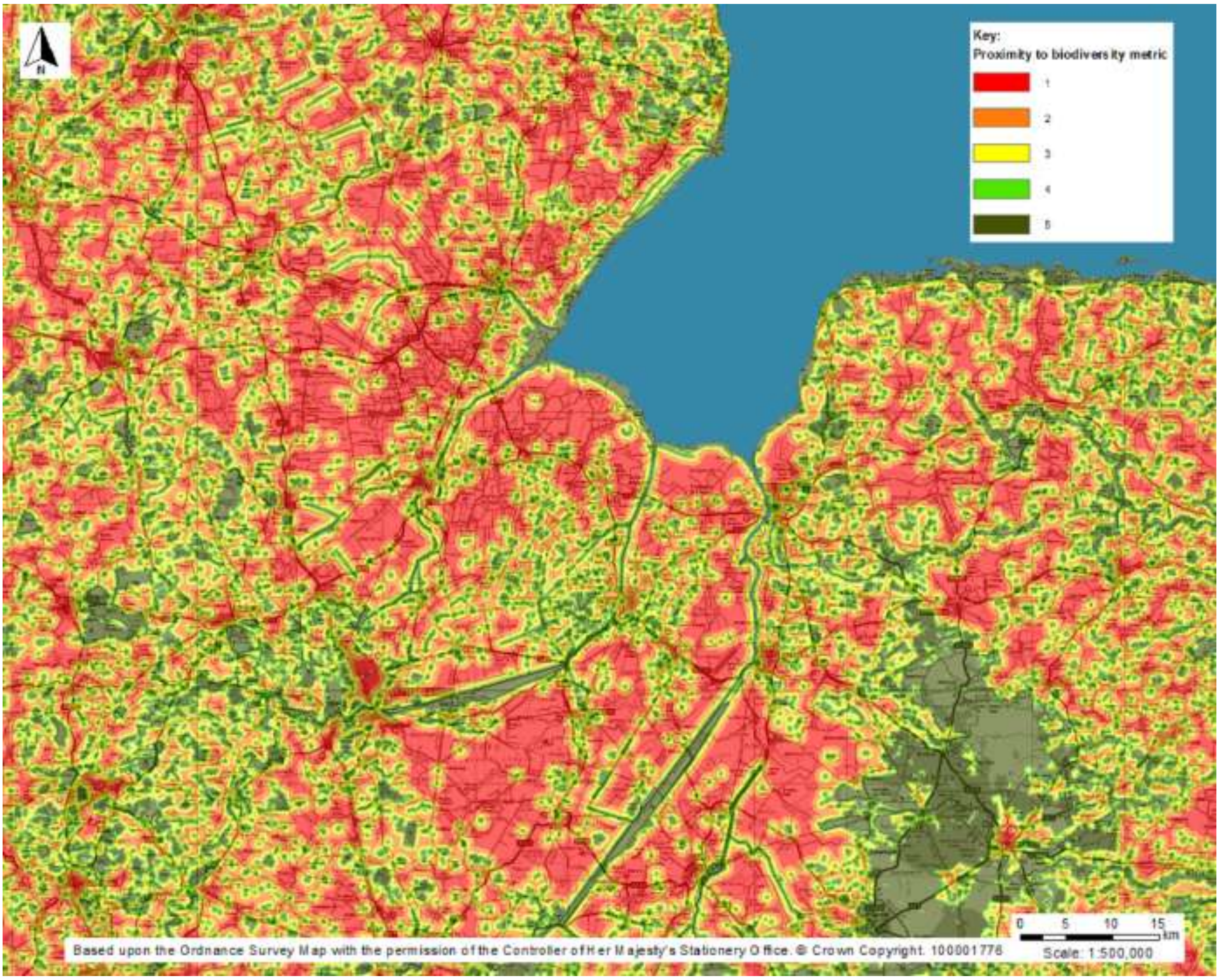


Plate 5.3 GIS Metric Outputs – Proximity to Biodiversity

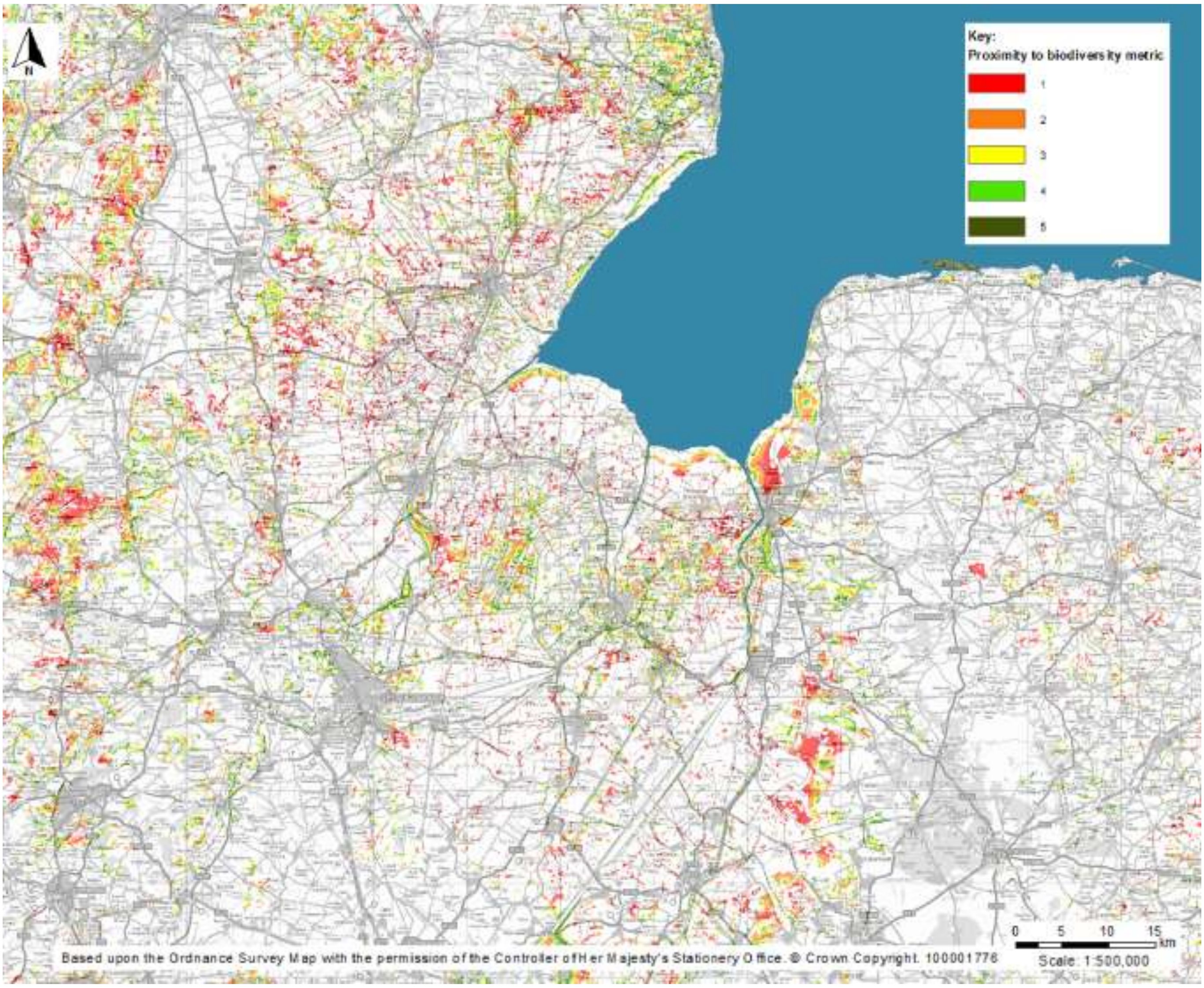


Plate 5.4 GIS Metric Outputs – Proximity to Biodiversity with Mask

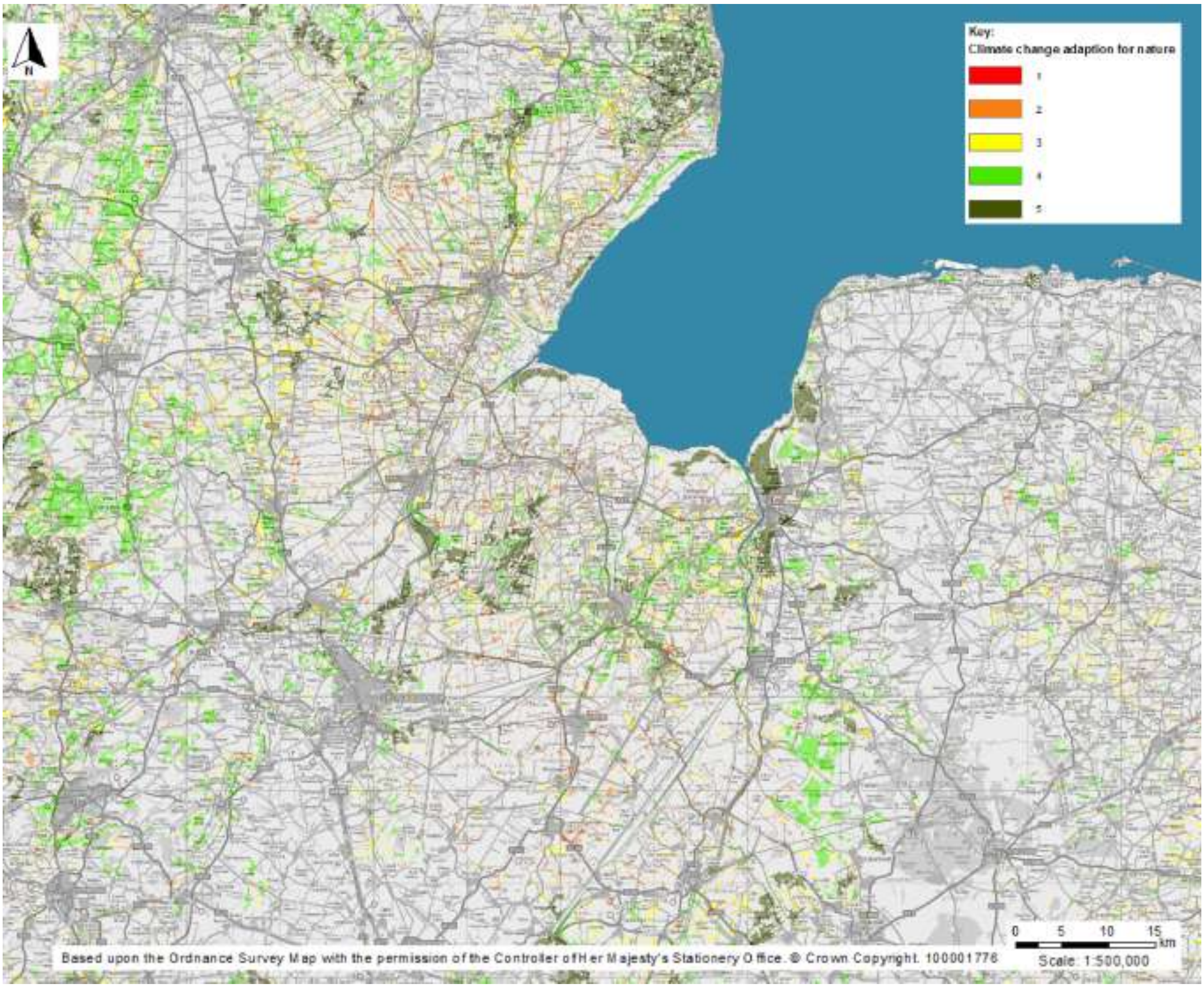


Plate 5.5 GIS Metric Outputs - Climate Change Adaption for Nature with Mask

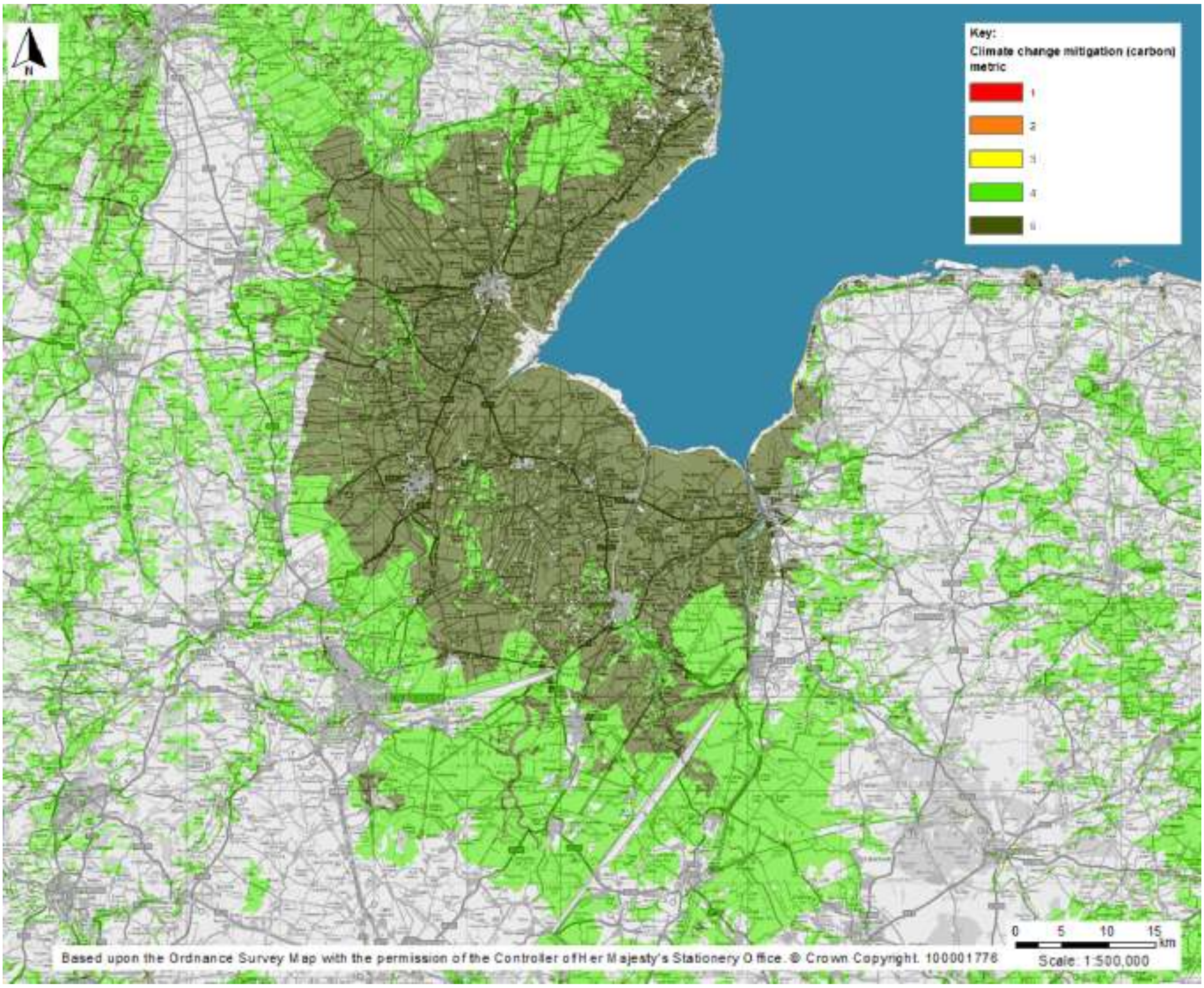


Plate 5.6 GIS Metric Outputs – Climate Change Mitigation (Carbon)

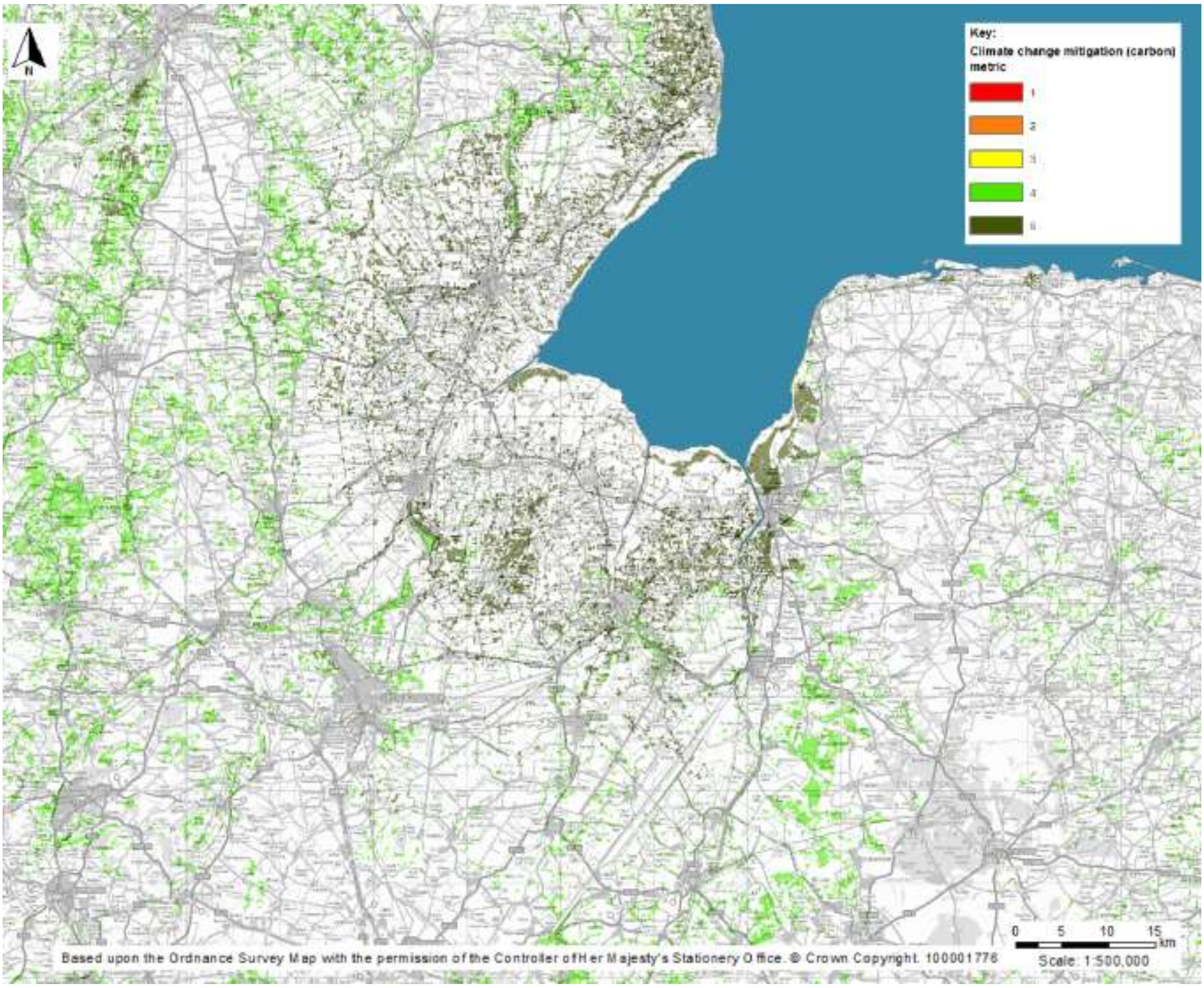


Plate 5.7 GIS Metric Outputs – Climate Change Mitigation (Carbon) with Mask

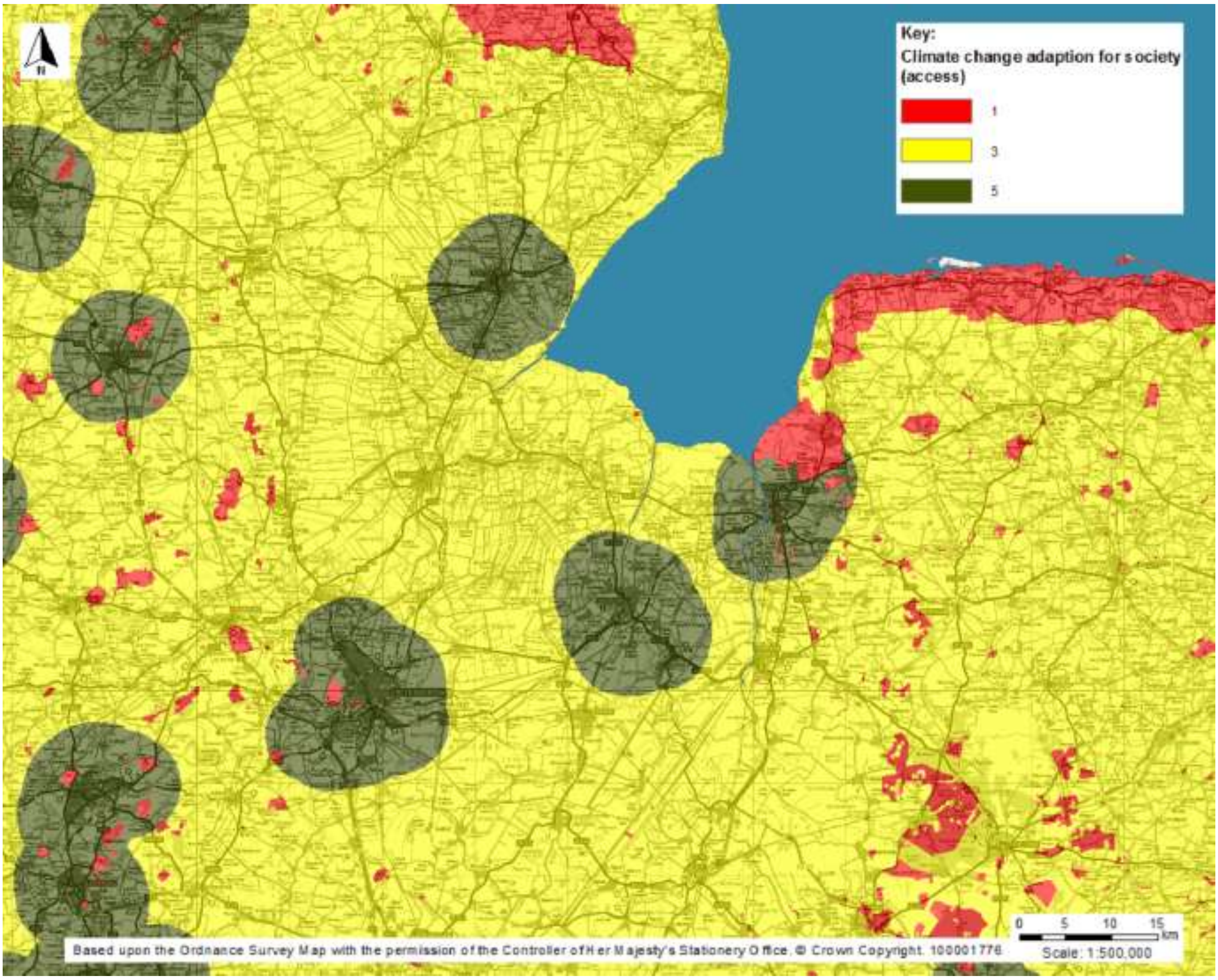


Plate 5.8 GIS Metric Outputs – Climate Change Adaption for Society (Access)

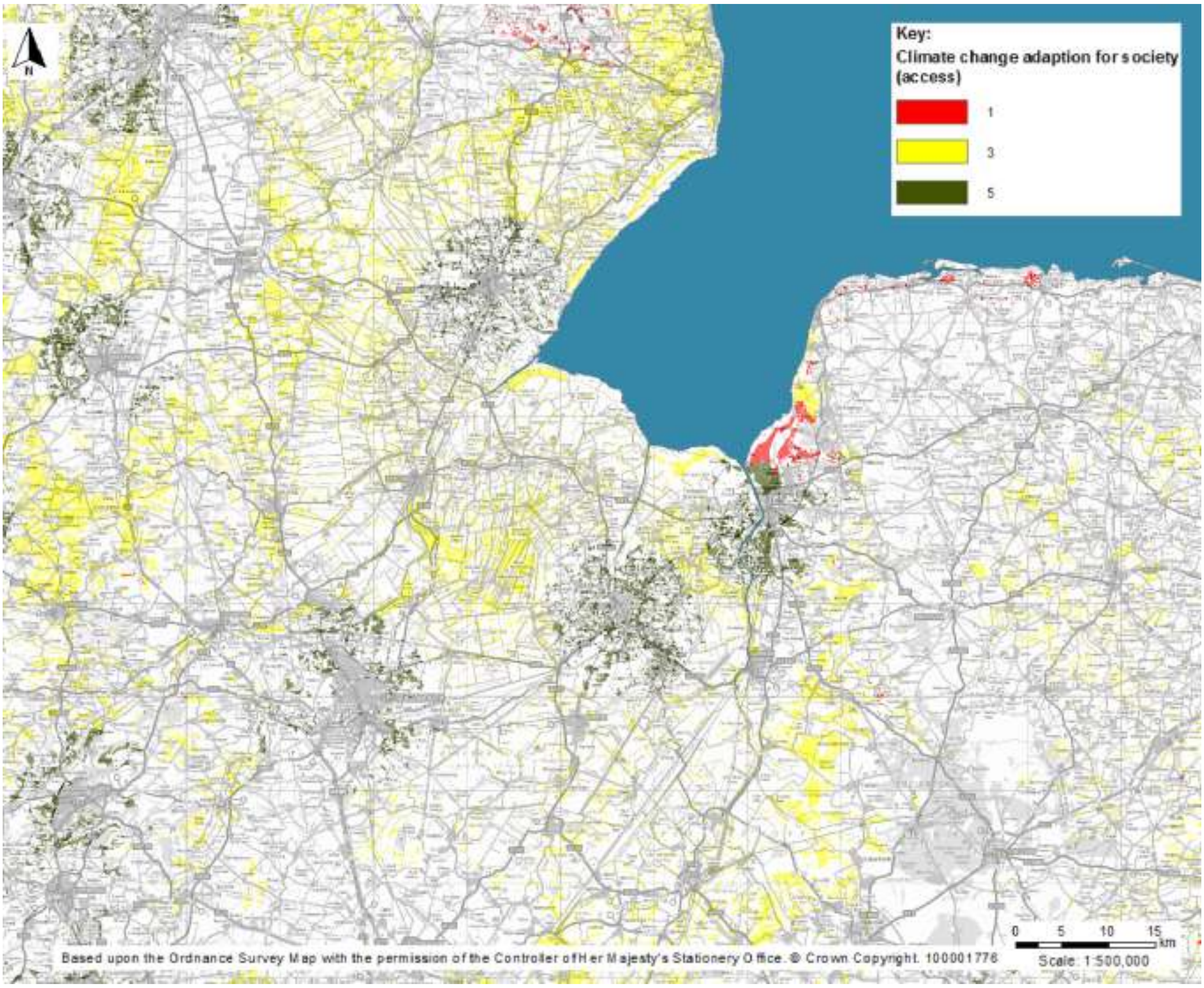


Plate 5.9 GIS Metric Outputs – Climate Change Adaption for Society (Access) with Mask

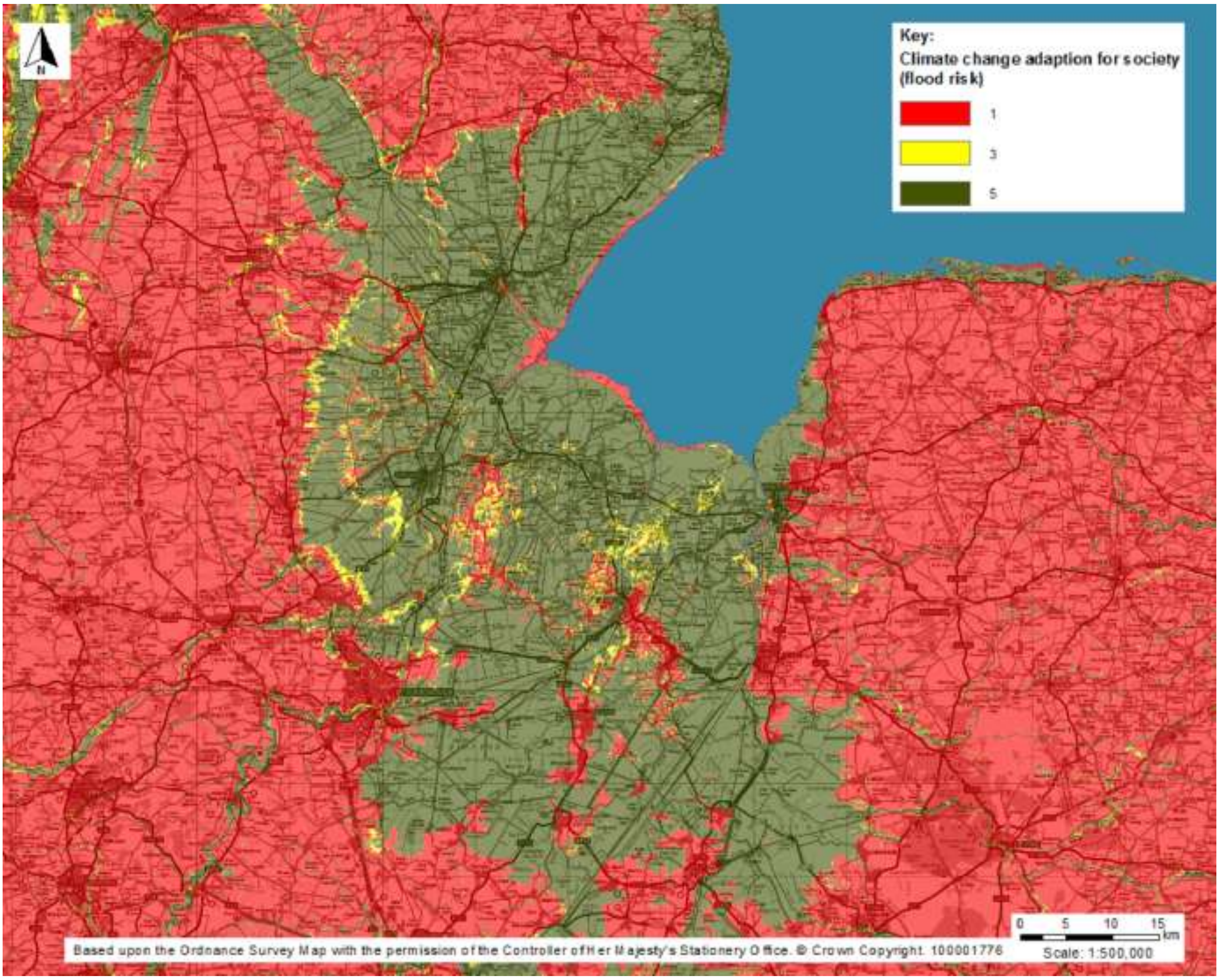


Plate 5.10 GIS Metric Outputs – Climate Change Adaption for Society (Flood Risk)

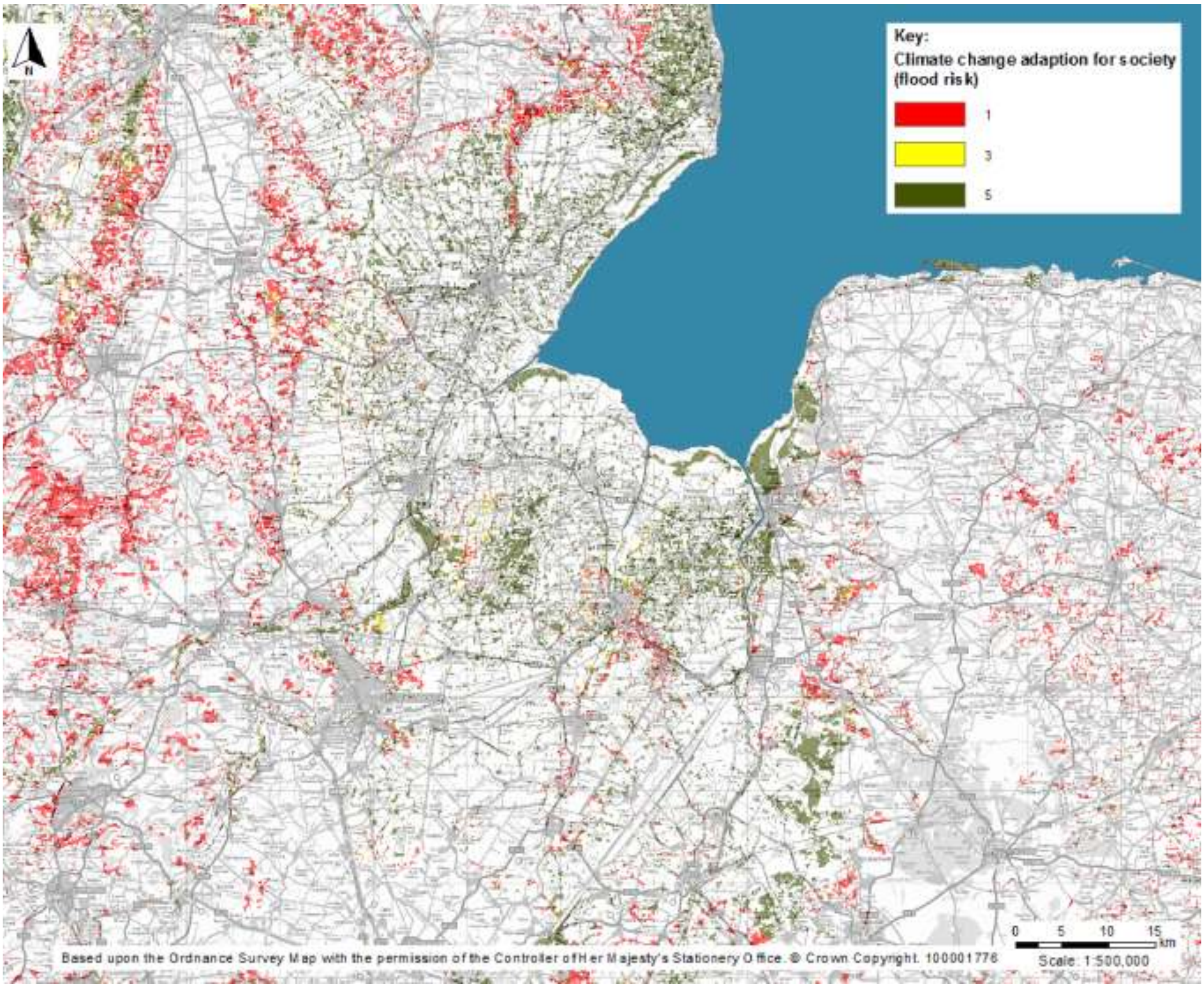


Plate 5.11 GIS Metric Outputs - Climate Change Adaption for Society (Flood Risk) with Mask

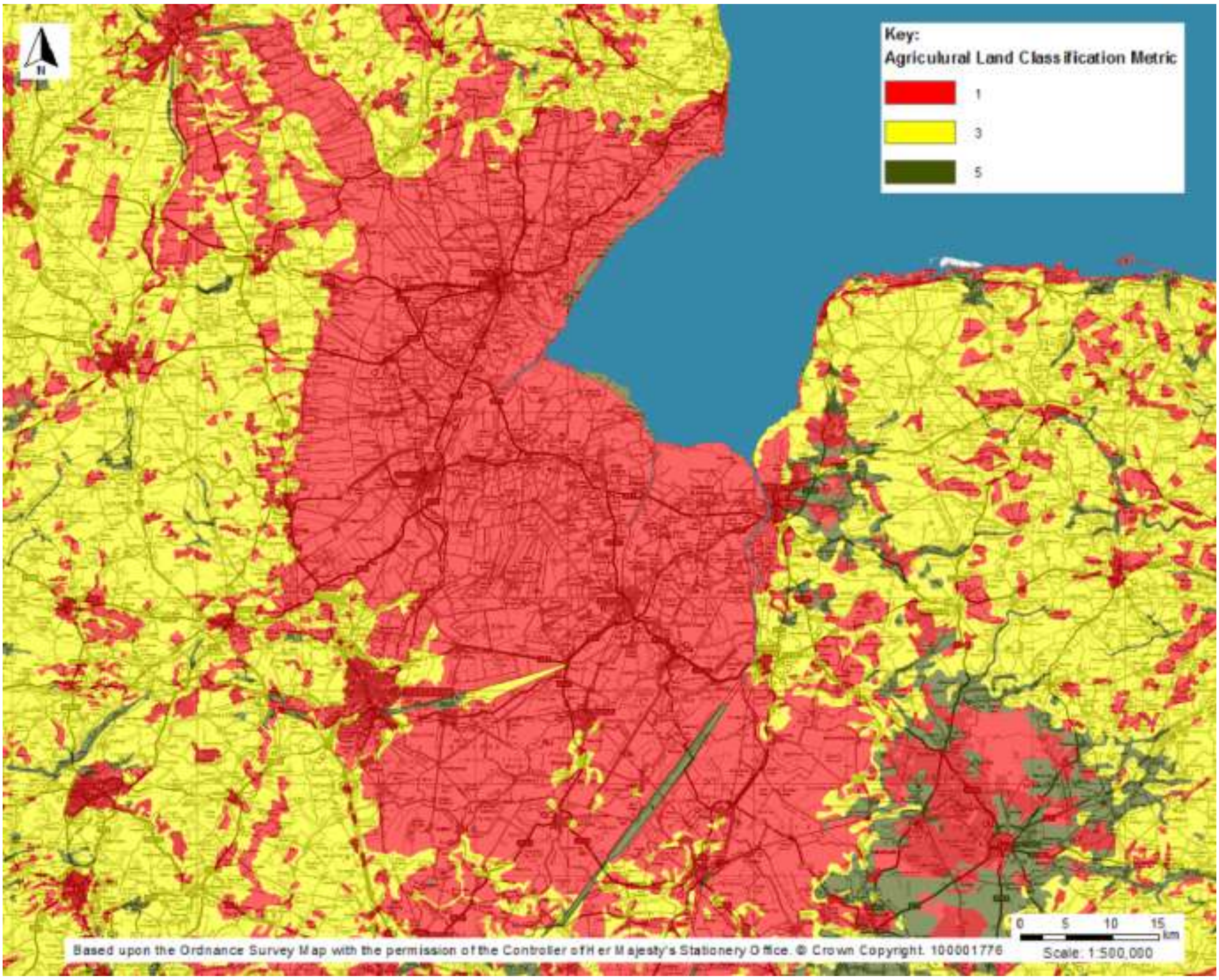


Plate 5.12 GIS Metric Outputs – Agricultural Land Classification

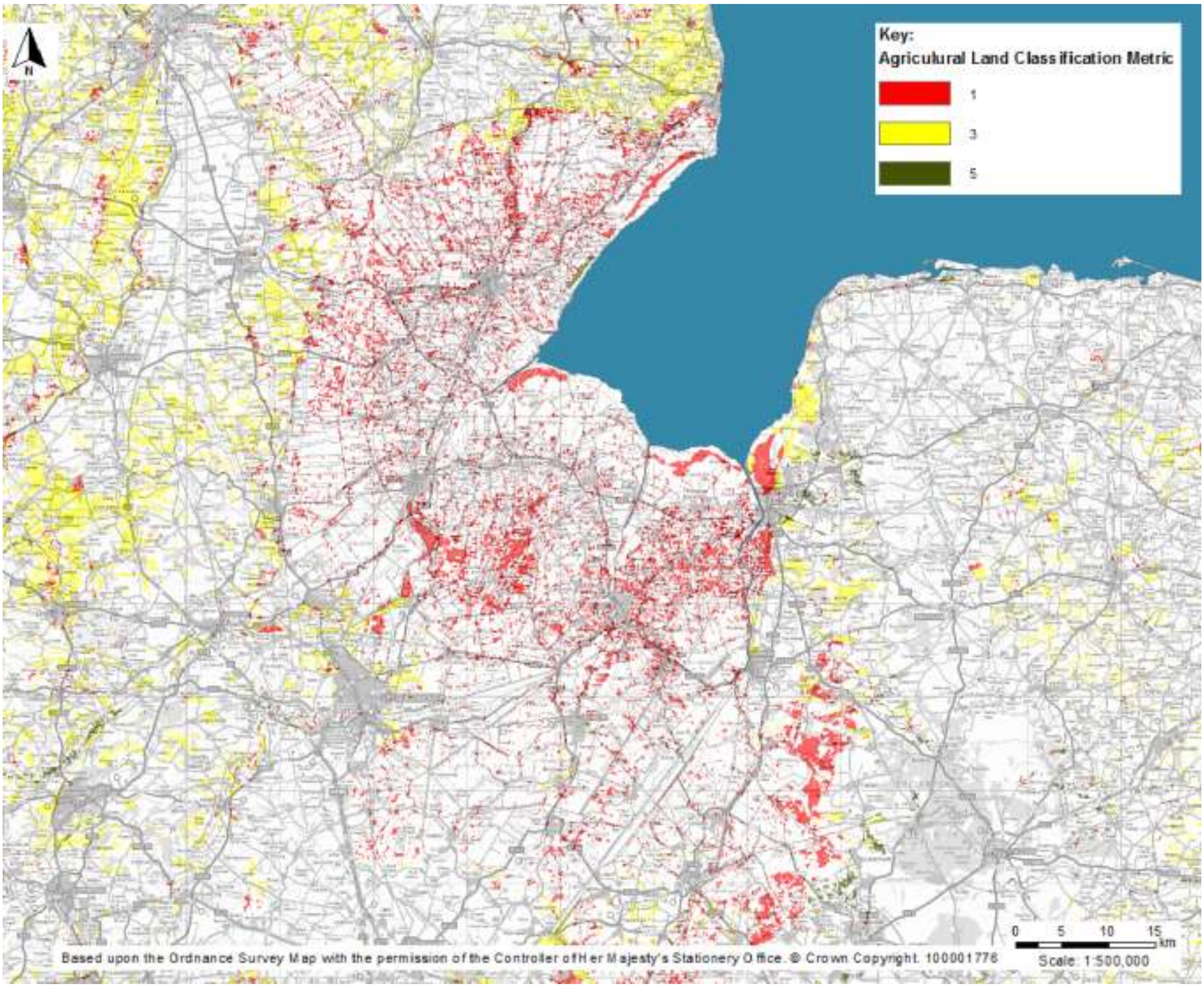


Plate 5.13 GIS Metric Outputs – Agricultural Land Classification with Mask

5.4 Identifying Land for the Outcome 1D target

The final part of the GIS analysis process was the preparation of a combined suitability layer using the six individual metrics. This was prepared using the ArcGIS-Spatial Analyst-Weighted Overlay operation with each layer assigned the same weight. This model is shown in Plate 5.14.

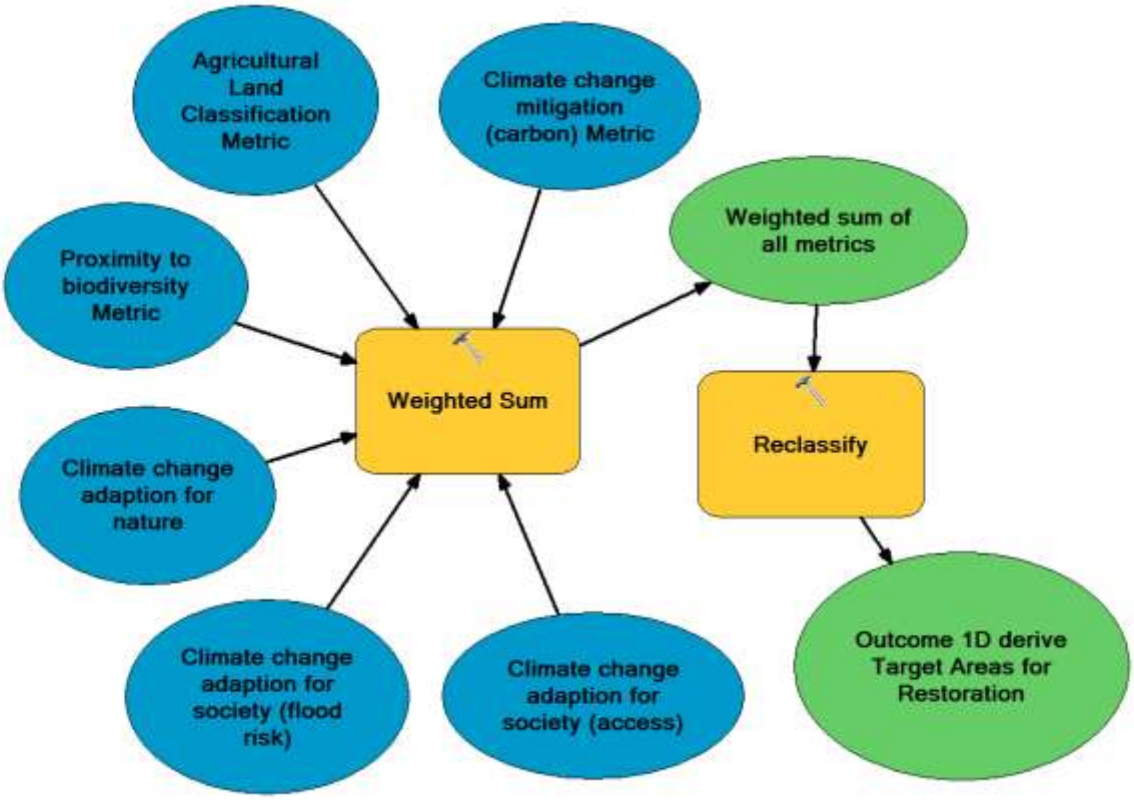


Plate 5.14 Outcome 1D – Weighted Overlay Model for Individual Metrics

The output of this model was a GIS layer with a score from 0-30 indicating relative suitability for future habitat restoration. The highest scoring 15% (by area) of degraded habitat is indicated by metric scores of 21 (covers highest scoring 18.5%) – 22 (covers highest scoring 12.5%). The output from this model is shown below in Plate 5.15, with green, blue and purple colours indicating locations with a metric score of 21 and above and ultimately the priority areas to be assessed at a local level for their potential to contribute to the delivery of Outcome 1D target. The top 15% based on metric scores falls between 117,702ha and 175,257ha.

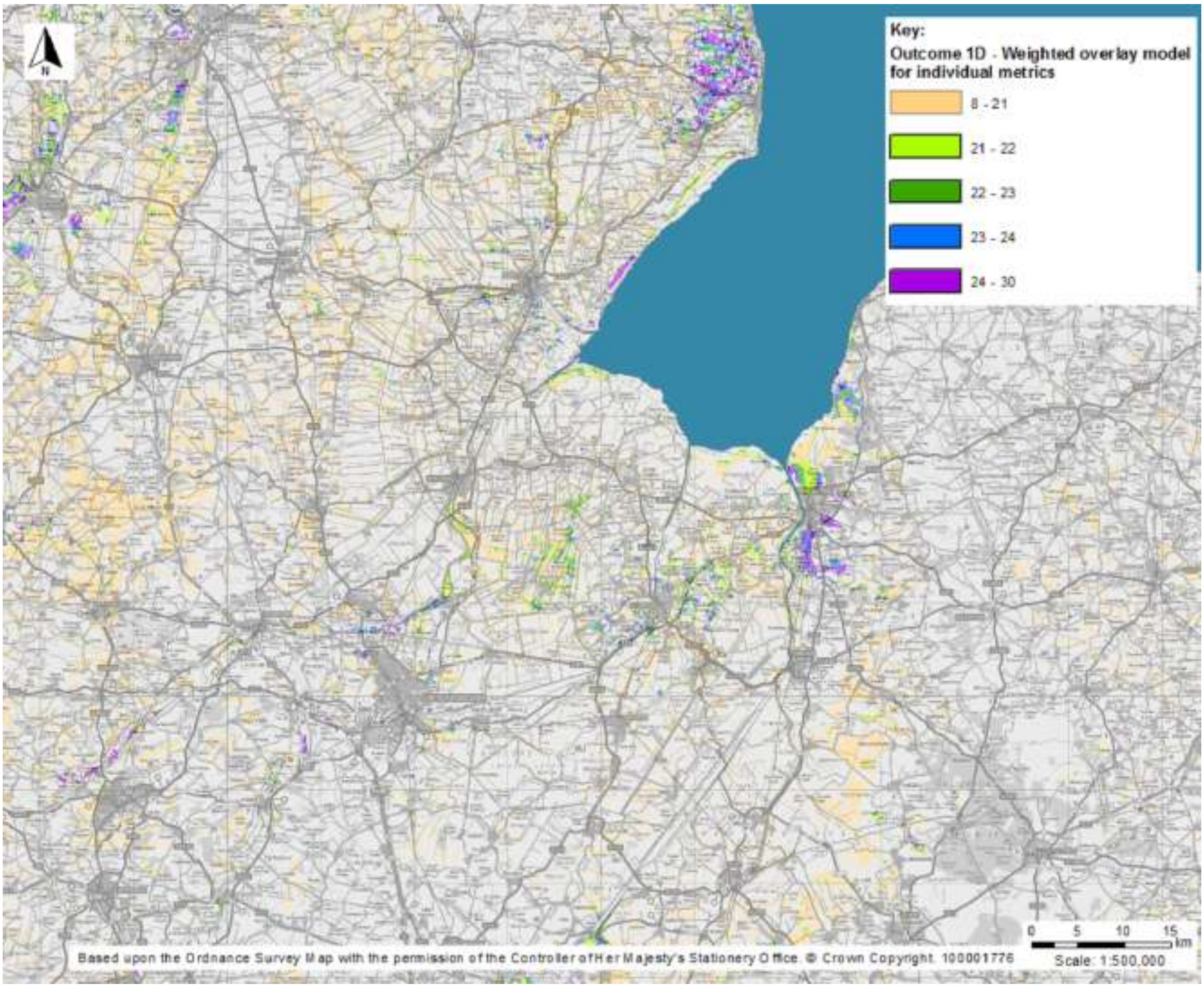


Plate 5.15 Outcome 1D – Weighted Overlay Model for Individual Metrics

5.5 Composition of the Highest Scoring 15% of Degraded Habitat

The composition of the areas with metric scores of 21 and 22 comprise the habitat/habitat combinations presented in Table 5.12.

It is clear that fen and coastal and floodplain grazing marsh are the two dominant habitats by area. This is probably to be expected as these were the two dominant habitats by area in respect of the baseline areas of potential. It is also notable that coastal habitats are represented by very low areas. This is also probably to be expected as their spatial extent is constrained at the coast and they are represented by very low areas of baseline potential in Table 3.4. Additionally, the Dudley Stamp data did not specifically map coastal habitats. However as losses of coastal habitats are most likely to have been to coastal erosion since 1940, this is not considered a major constraint but, as indicated previously, does probably mean that the losses of coastal habitat since 1940 are under-represented in the analysis.

Table 5.12 Composition of the Areas with the Highest Metric Scores

Habitat/ Habitat Combinations	Metric Score 21 Area (ha)	Metric Score 21 % of the Total	Metric Score 22 Area (ha)	Metric Score 22 % of the Total
Fen	27,644	15.77%	10,378	8.82%
Fen, reedbed	4,342	2.48%	3,139	2.67%
Coastal floodplain grazing marsh	2,943	1.68%	2,096	1.78%
Coastal floodplain grazing marsh, fen	34,420	19.64%	25,117	21.34%
Coastal floodplain grazing marsh, fen, reedbed	98,609	56.27%	72,824	61.87%
Blanket Bog	6,007	3.43%	3,277	2.78%
Other combinations	1,291	0.74%	871	0.74%
Totals	**175,257ha**		**117,702ha**	

6. Ease of Habitat Transformation/ Restoration

6.1 Approach

Defining the ease and cost of habitat transformation and restoration for each of the nine habitats was based upon/ adapted from the research, approaches and information contained in the following guidance documents and using professional judgement and experience, where information gaps for certain habitats existed in the referenced documents:

- DEFRA project 'Developing Datasets for Biodiversity 2020: Outcome 1D (Omnicom 24951/ITT455)' (Entec, 2011); the calculations and rationale from this report are provided in Appendix D; and
- 'UK Biodiversity Action Plan: Preparing Costings for Species and Habitat Action Plans' (GHK Consulting, 2006).

6.2 Outputs

Ease of Creation

The ranking of 'ease of creation' is indicative only ('high-level') as many factors (and their magnitude) will influence the actual ease of creation on the ground at any one location, and the scoring methodology could be weighted differently resulting in different scores and rankings.

The 'ease of creation' ranking for each of the nine habitats is provided in Table 6.1, with blanket bog and lowland raised bog being the hardest to create; reedbed is the easiest to create. The detailed result of the ease of creation scoring is provided in Table 6.2.

Table 6.1 Ease of Creation – Habitats Ranked

Habitat	Rank	Score*
Blanket Bog	1 (Hardest)	43
Lowland Raised Bog	1	43
Lowland Fen	3	28
Coastal Saltmarsh	4	27
Coastal Sand Dunes	5	24
Coastal Vegetated Shingle	6	18
Coastal and Floodplain Grazing Marsh	7	17
Maritime Cliffs & Slopes	8	16
Reedbed	9	14

Table Notes: See Table 6.2 for detailed scoring
No ease of creation assessment has been undertaken for orchards but if it was, these would be expected to be ranked as the easiest to create.

Table 6.2 Ease of Creation – Detailed Scoring Results[1, 3]

	Coastal Saltmarsh		Coastal Sand Dunes		Coastal Vegetated Shingle		Maritime Cliffs & Slopes		Coastal and Floodplain Grazing Marsh		Blanket Bog		Lowland Raised Bog[2]		Lowland Fen		Reedbed	
	Option	Score	Option	Score	Option	Score	Option	Score	Option	Score	Option	Score	Option	Score	Option	Score	Option	Score
Timescales	A	1	B	2	A	1	A	1	A	1	C	5	C	5	B	2	A	1
Size (ha) (min. extent)	B	2	C	5	B	2	B	2	B	2	C	5	C	5	C	5	B	2
Method of creation	C	5	C	5	C	5	B	2	B	2	C	5	C	5	C	5	B	2
Hydrological regime	B	2	B	2	A	1	A	1	B	2	C	5	C	5	C	5	A	1
Trophic status	C	5	C	5	A	1	B	2	B	2	D	15	D	15	B	2	B	2
Substrate availability	C	5	B	2	C	5	A	1	A	1	C	5	C	5	C	5	B	2
Source of biological material	C	5	B	2	B	2	B	2	B	2	B	2	B	2	B	2	B	2
Management	B	2	A	1	A	1	C	5	C	5	A	1	A	1	B	2	B	2
Score		**27**		**24**		**18**		**16**		**17**		**43**		**43**		**28**		**14**

Table Notes:
[1] adapted from Entec (2011). All scores are out of a maximum of 50. All scores derived from professional judgement and experience, and results from Entec (2011)
[2] Lowland raised bog is scored the same as blanket bog.
[3] No ease of creation assessment has been undertaken for orchards but if it was, these would be expected to be ranked as the easiest to create.

Cost of Habitat Creation

The total overall cost to create each of the nine habitats is made up of three individual components as follows:

- Creation cost;
- Land purchase cost/ incentive (compensation) cost;
- Post-creation management cost.

As noted in GHK (2006) it is considered that in many cases the actual purchase of land will not be necessary. Instead appropriate action under existing private ownership could be realised using appropriate financial incentives (likely to be provided through Agri-environment schemes). The land-purchase costs (a one-off lump sum) and an incentive-based (financial compensation) approach over a number of years may amount to the same price[9]. Therefore the costings include a 'land purchase/ incentive' costing.

The costs provided are considered indicative only ('high-level') as many factors will influence the actual costs including where in the country the habitat is to be created the prevailing land price at the time of creation, the scale of the creation at any one location, the establishment success of the habitat and any remedial action required in addition to regular management.

The overall cost for creating and managing 15% priority habitats over a 5 year period (without land-purchase or landowner compensation costs) is estimated to be in the region of between £383 and £541 million, as shown in Table 6.3 and 6.4, corresponding to a total created area of between 117,702 and 175,257 hectares respectively. If land purchase costs are included these figures jump to between £2.4 and £3.5 billion.

An upper and lower range of values is given for the reasons described in Section 5.5.

The indicative unit-cost for each of the nine habitats is provided in Table 6.5. The scope of what the creation costs covers and the associated terminology (as taken from GHK, 2006), is provided in Table 6.6. Table 6.7 shows the habitats ranked according to cost of creation per hectare, with coastal saltmarsh being the most expensive to create per hectare and blanket bog the least expensive to create per hectare.

[9] GHK (2006) gives the example where purchasing a hectare of farmland at £ per hectare (adjusted for 2013 prices) would equate to compensating landowners for the loss of agricultural productivity of £ per hectare over ten years

Table 6.3 Cost of Creation – Overall Cost (GIS Weighting Scores of 21 and above = 18.5% of Area Analysed)

Habitat/ Habitat Combinations			Area (ha)	Unit Cost with Land Cost (£)[1]	Totals with Land Cost (£millions)	Unit Cost without Land Cost (£)	Totals without Land Cost (£millions)
Fen			27,644	18,640	515	1,380	38
Fen, reedbed			4,342	19,300	84	2,040	9
CFGM			2,943	20,830	61	3,570	11
CFGM, fen			34,420	20,830	717	3,570	123
CFGM, fen, reedbed			98,609	20,830	2,054	3,570	352
Blanket bog			6,007	18,130	109	870	5
Sub-total	**-**	**-**	173,966	-	3,540	-	538
Other habitat combinations	**-**	**-**	1,291	20,164[†]	26	2,904[†]	4
TOTALS	**-**	**-**	175,257	-	3,566	-	541

Table notes:
[1]: Where more than 1 habitat is present, the highest costing habitat unit has been used
[2]: CFGM: coastal and floodplain grazing marsh
[†]: this is an average of the unit costs for the 9 habitats
*: to the nearest thousand hectares

Table 6.4 Cost of Creation – Overall Cost (GIS Weighting Scores of 22 and above = 12.5% of Area Analysed)

Habitat/ Habitat Combinations			Area (ha)	Unit Cost with Land Cost (£)[1]	Totals with Land Cost (£millions)	Unit Cost without Land Cost (£)	Totals without Land Cost (£millions)
Fen			10,378	18,640	193	1,380	14
Fen, reedbed			3,139	19,300	61	2,040	6
CFGM			2,096	20,830	44	3,570	7
CFGM, fen			25,117	20,830	523	3,570	90
CFGM, fen, reedbed			72,824	20,830	1517	3,570	260
Blanket bog			3,277	18,130	59	870	3
Sub-total	**-**	**-**	116,831	-	2,397	-	381
Other habitat combinations	**-**	**-**	871	20,164†	18	2,904†	3
TOTALS	**-**	**-**	117,702	-	2,415	-	383

Table notes:
[1]: Where more than 1 habitat is present, the highest costing habitat unit has been used
[2]: CFGM: coastal and floodplain grazing marsh
†: this is an average of the unit costs for the 9 habitats
*: to the nearest thousand hectares

Table 6.5 Cost of Creation Per Hectare – Detailed Results[1,5]

Unit Cost per Ha	Coastal Saltmarsh	Coastal Sand Dunes	Coastal Vegetated Shingle	Maritime Cliffs and Slopes	Coastal and Floodplain Grazing Marsh	Blanket Bog	Lowland Raised Bog	Lowland Fen	Reedbed
Capital cost – Habitat Creation[2]	6050	2420	4840	180	1550	610	990	990	1650
Management Cost (5 years) [3]	660	900	320	960	2020	260	960	390	390
Sub-totals	**6710**	**3320**	**5160**	**1140**	**3570**	**870**	**1950**	**1380**	**2040**
Capital Cost – Land Purchase/ Incentive (Compensation) [4]	17260	17260	17260	17260	17260	17260	17260	17260	17260
TOTALS	**23970**	**20580**	**22420**	**18400**	**20830**	**18130**	**19210**	**18640**	**19300**

Table Notes:
[1] Cost adapted from GHK (2006). Costs multiplied by 3% inflation rate per year since; therefore multiplied by 21% for 2006 costs (3% x 7 years). Costs rounded to nearest £10.
[2] Assumed to be a one-off lump sum. See Table 6.6 for what the creation cost covers.
[3] Cost expressed as a total amount covering 5 years management; assumes and includes inflation is at 3% per year for 5 years between 2013 and 2018 inclusive.
[4] The Average price per hectare for farmland in 2012 was £6,783 per acre (£16,754 per hectare) – information taken from: http://www.rics.org/uk/knowledge/news-insight/press-releases/farmland-prices-reach-record-high. These costs were multiplied by 3% to allow for inflation between 2012 and 2013.
[5] No costs presented for traditional orchard albeit it would be expected to be (perhaps) the cheapest.

Table 6.6 Scope of Creation Costs

Habitat	What the Creation Cost Covers and the Terminology Used in GHK (2006)
Coastal Saltmarsh	‘Creation’ (includes dismantlement of flood defences and provision of technical expertise; the land price given in the cost in GHK (2006) has been excluded in this creation cost
Coastal Sand Dunes	‘Restoration’ (clearance of woodland)
Coastal Vegetated Shingle	‘Expansion’ (conversion of agricultural land, soil removal, import of shingle; the land price (£6000) given in the ‘expansion’ cost of £10,000 in GHK (2006) has been excluded giving rise to £4000)
Maritime Cliffs & Slopes	‘Habitat re-creation’ (conversion of arable or improved grassland, turf stripping)
Coastal and Floodplain Grazing Marsh	‘Restoration/re-establishment’ (water control structures, land-forming to create drain and grass re-seeding)
Blanket Bog	‘Restoration of degraded bog’ (assumes that blanket bog cannot be readily created from nothing and focuses on restoring existing degraded areas; costs include tree removal, drain blocking, rehabilitation of burnt/eroded areas)
Lowland Raised Bog	‘Restoration’ (assumes that raised bog cannot be readily created from nothing and focuses on restoring existing degraded areas scrub clearance, woodland clearance, water level management with structures; the land price given in the cost in GHK (2006) has been excluded in this creation cost)
Lowland Fen	‘Expansion / re-establishment’ (digging out dry areas, water level management with structures, scrub clearance/cutting and re-seeding)
Reedbed	‘Expansion / re-establishment’ (creation of lagoons, water level management with structures, planting, cutting, weed control)

Table 6.7 Cost of Creation – Habitats Ranked According to Cost Per Unit

Habitat	Rank	Cost (£/ha)*
Coastal Saltmarsh	1 (most costly)	23,970
Coastal Vegetated Shingle	2	22,420
Coastal and Floodplain Grazing Marsh	3	20,830
Coastal Sand Dunes	4	20,580
Reedbed	5	19,300
Lowland Raised Bog	6	19,210
Lowland Fen	7	18,640
Maritime Cliffs & Slopes	8	18,400
Blanket Bog	9 (least costly)	18,130

Table Notes: * includes creation and 5 year management but excludes land-purchase/ incentive costs.
No costs presented for traditional orchard albeit it would be expected to be (perhaps) the cheapest.

Cost and Ease of Creation Combined

Table 6.8 shows the habitats ranked according to total cost of creation using the GIS weighting scores applied, and the associated ease of creation scores. An upper and lower range of values is given for the reasons described in Section 5.5.

The 'coastal and floodplain grazing marsh/ fen / reedbed' habitat combination is the most expensive to implement because it would yield up to 98,600[10] hectares of created habitat at a cost of up to £213 million (exc.VAT) (Table 6.8).

The information in Table 6.8 and from Table 6.7 translates into a matrix which matches the TOTAL cost of creating each habitat/ habitat combination with the ease of creation (Plate 6.1). By reference to Plate 6.1 it can be seen that:

- No habitat or habitat combination is the hardest to create as well being the most costly to create (no habitat appears in the 'red' section of the matrix); and
- Coastal and floodplain grazing marsh / fen / reedbed is nearly the easiest to create but will be the most costly based on total area to be created.

Table 6.8 Cost of Creation – Habitats Ranked According to Total Cost

[10] Rounded to the nearest 100 ha

Habitat/ Habitat Combinations	Rank[1]	Extent Created Range (ha)*	Total Cost Range (£millions)[2 *]	Associated Ease of Creation Score[3]
Coastal floodplain grazing marsh, fen, reedbed	1(most costly)	72,824 – 98,609	260 - 352	20
Coastal floodplain grazing marsh, fen	2	25,117 – 34,420	90 - 123	23
Fen	3	10,378 – 27,644	14 - 38	28
Coastal floodplain grazing marsh	4	2,096 – 2,943	7 - 11	17
Fen, reedbed	5	3,139 – 4,342	6 - 9	21
Blanket Bog	6	3,277 – 6,007	3 - 5	43
Other combinations (various)	7 (least costly)	871 – 1,291	3 - 4	26[†]

Table Notes:
[1] ranked according to highest (upper) value in the total cost range in the last column of the table (e.g. for coastal and floodplain grazing marsh / fen / reedbed the upper value is £352 million
[2] includes creation and 5 year management but excludes land-purchase/ incentive costs
[3] Where there is more than one habitat, an average score is taken from summing the individual habitat scores except where indicated otherwise
[†] this is derived by taking an average of the sum of all the individual habitat scores
* range represents the cost/area for scores of 21 and above, and scores of 22 and above – see Tables 6.3 and 6.4.

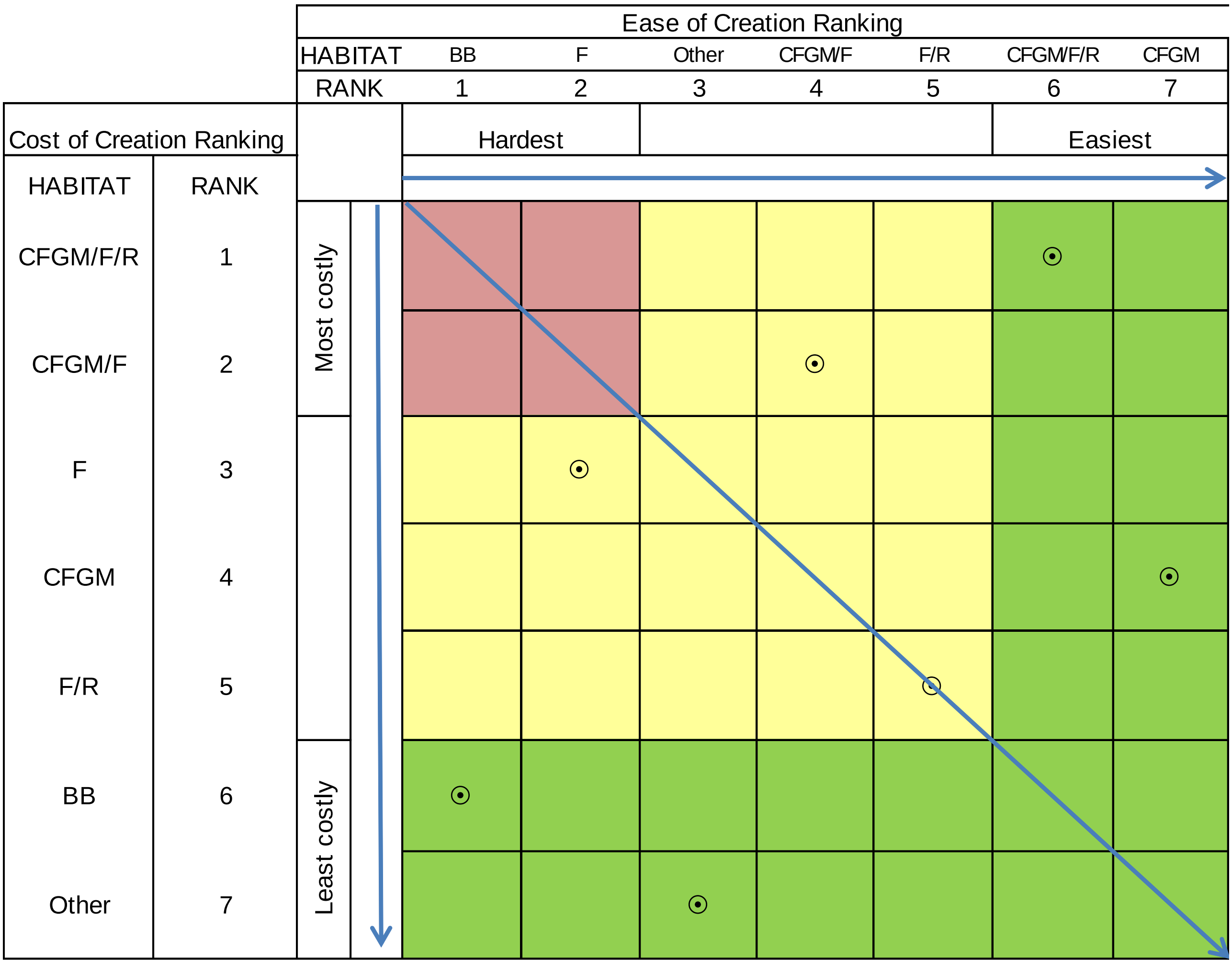


Plate 6.1 Ease of Creation Matched with Total Cost of Creation

Plate Notes: The closer the symbol to the diagonal line, the more closely balanced are the ease of creation and cost of creation. Red: Hardest/most costly; Yellow: Moderately hard/moderately costly; Green: Easiest/least costly; CFGM: Coastal and Floodplain Grazing Marsh; R: Reedbed; F: Fen; BB: Blanket Bog; Other: Other combinations of the 9 habitats.

7. Conclusions and Suggestions

7.1 Conclusions

Biodiversity 2020 (Defra, 2011) outlined the Government's strategy for biodiversity conservation in England, with a series of outcomes to be achieved by 2020. Outcome 1 states that:

> *"By 2020 we will have put in place measures so that biodiversity is maintained and enhanced, further degradation has been halted and where possible, restoration is underway, helping deliver more resilient and coherent ecological networks, healthy and well-functioning ecosystems, which deliver multiple benefits for wildlife and people including:*
>
> ***Outcome 1A**. Better wildlife habitats with 90% of priority habitats in favourable or recovering condition and at least 50% of SSSIs in favourable condition, while maintaining at least 95% in favourable or recovering condition;*
> ***Outcome 1B**. More, bigger and less fragmented areas for wildlife, with no net loss of priority habitat and an increase in the overall extent of priority habitats by at least 200,000 ha;*
> ***Outcome 1C**. By 2020, at least 17% of land and inland water, especially areas of particular importance for biodiversity and ecosystem services, conserved through effective, integrated and joined up approaches to safeguard biodiversity and ecosystem services including through management of our existing systems of protected areas and the establishment of nature improvement areas;*
> ***Outcome 1D**. Restoring at least 15% of degraded ecosystems as a contribution to climate change mitigation and adaptation".*

This project has been undertaken to inform Outcome 1D but the outputs are expected to contribute to the Outcome 1B target also in respect of the requirement to increase the overall extent of priority habitats by at least 200,000 ha. In this report degraded habitat has been interpreted as habitat that can be shown has been lost compared to the baseline used. The key objectives of this Outcome 1D project were:

- To establish a baseline area of 'potential' key priority habitats for climate change. These are areas of potential woodland, wetland and coastal habitats, which do not currently qualify as priority habitat but could be restored to priority habitat status (c.f. Outcome 1B);
- To assess the relationship between habitat condition and key ecosystem functions such as carbon sequestration and storage;
- To develop a system for mapping degraded ecosystems to facilitate spatial analysis by Natural England staff to identify key locations for restoration and to assess progress of the 1D target.

The outputs against these objectives were achieved following the process outlined in Plate 7.1.

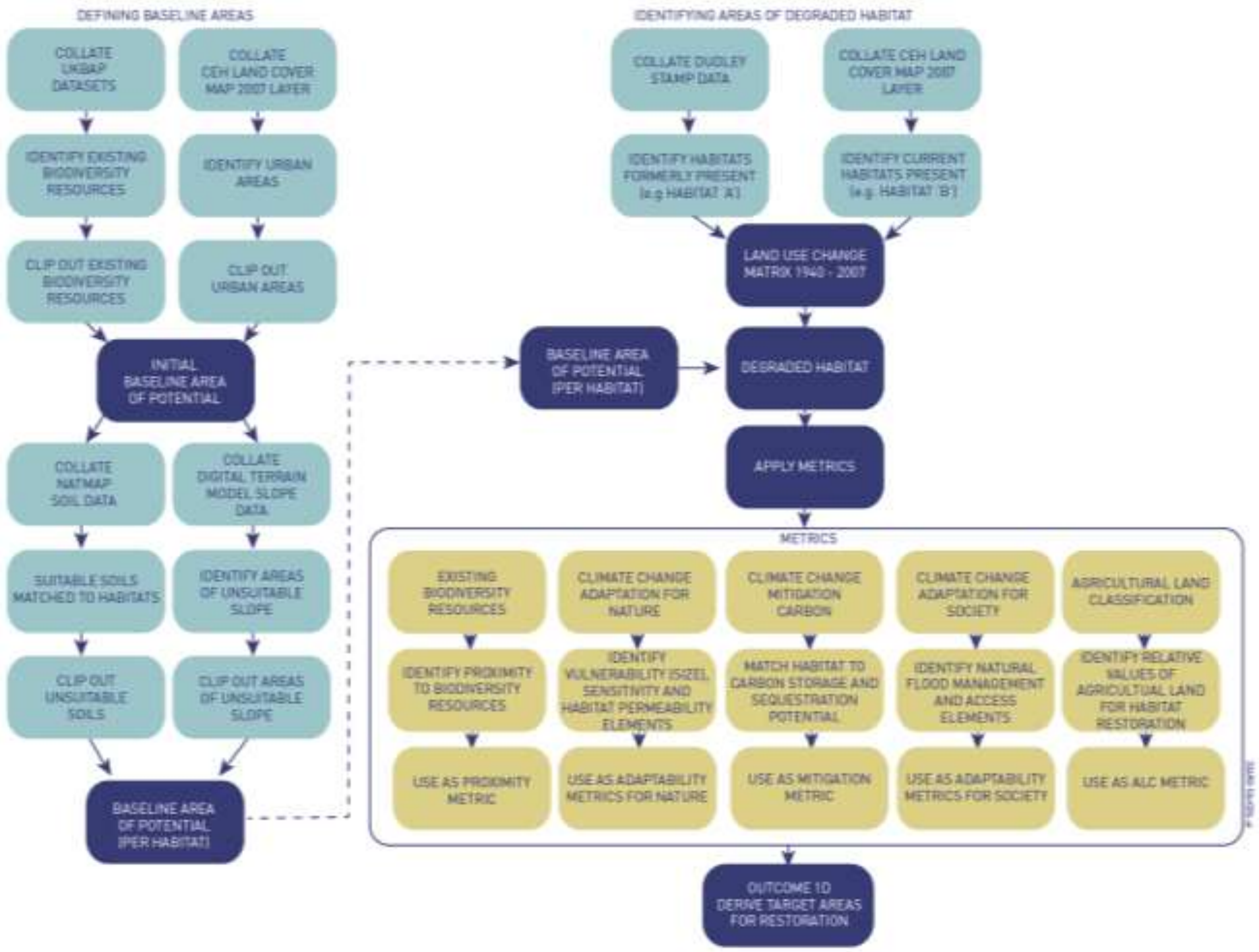


Plate 7.1 Overview of the Process to Identify Target Areas for Outcome 1D

Nine priority habitats were initially included in this project: coastal saltmarsh, coastal sand dunes, coastal vegetated shingle, maritime cliffs & slopes, coastal and floodplain grazing marsh, blanket bog, lowland raised bog, lowland fens and reedbeds. Traditional orchards were a late addition to the project, and were included in respect of analysis of extent of degraded habitat because they are mapped as an individual habitat in the 1940s Dudley Stamp data. Woodland and standing/ flowing water wetland UK priority habitats were excluded from this baseline dataset project because Natural England plan to rely on Forestry Commission and Water Framework Directive data respectively to consider these habitat types.

A fairly simple approach has been adopted to the identification of baseline areas of potential for each habitat using combinations of suitable soil types, slope conditions and floodplain locations to identify areas of habitat potential. The approach adopted is very similar to that, and uses some of the same environmental conditions, in the Wetland Vision project (Hume, 2008). However for some types of fen, notably groundwater fend fens, the Wetland Vision project undertook additional steps not repeated in this project. As a result, the fen potential areas developed in this Outcome 1D project are most similar to the Wetland Vision floodplain and eutrophic fens category. The implication of the differences in approach between the two projects is that some potentially suitable areas for fen, particularly those overlying aquifers, are omitted from the Outcome 1D datasets. This said, it is considered that the similarity between the fen potential areas developed in this project and those of the Wetland Vision floodplain and eutrophic fens category is the most useful in respect of the ability to create/restore habitat in the next 8 years.

The extent of baseline habitat potential for the target habitats was calculated as about 3.6 million ha, or about 28% of England.

Areas of degraded habitat have been derived by comparing habitat data from the 1940s (as represented by the Dudley Stamp dataset), with the Land Cover 2007 dataset and then cross-matching the results to areas of habitat potential. The analysis revealed that, following removal of blocks of less than 1ha in area, the extent of degraded habitat is 947,484 ha (ca 7.3% of England). As a result an indicative estimate of 15% target equates to about 142,122 ha (ca 1.1% of England). Although the Dudley Stamp dataset has limitations, it was considered the best available against which to define a baseline position. A further limitation on the analysis reported here is that orchards have only been included as degraded habitat where they coincide with areas of other habitat potential as a specific habitat potential layer for orchards was not derived. If Natural England wanted to focus efforts on orchards however it would be a straightforward task to simply compare the distribution of orchards as represented in the Dudley Stamp dataset and compare this with the current BAP inventory. Comparison of the two indicates that 72,000 ha that were orchard in 1940 have been lost and that while only 3,500ha that were orchards in 1940 still are, the Land Cover 2007 data indicates that there are 17,700 ha of orchards still in existence – so there has been some development of new areas since 1940. An additional consideration is that areas that were orchard in the 1940's are likely, by now, to have degraded unless replanted as fruit trees have a finite lifespan.

There is however clearly a need to target areas of restoration action to the lost suitable areas. To inform this targeting process six metrics have been defined to reflect current policy drivers (such as climate change) and also principles such as consideration of distance to existing biodiversity resources and the likely requirement to avoid restoring habitat on high grade agricultural land. The metrics were:

- Proximity to existing biodiversity;
- Climate change (carbon) mitigation;
- Climate change adaptation for nature (vulnerability);
- Climate change adaptation for society (flood risk)

- Climate change adaptation for society (access);
- Agricultural land classification.

The GIS analysis using these metrics weighted them all equally. The highest scoring 15% (by area) of degraded habitat is indicated by metric scores of 21 (covers highest scoring 12.5%) – 22 (covers highest scoring 18.5%). The top 15% based on metric scores falls between 117,702ha and 175,257ha. The most abundant habitats by area were coastal and floodplain grazing marsh, fen and a combination of these two with reedbed.

The ease of creation of habitats has been ranked based on the method developed by Entec (2011). Blanket bog and lowland raised bog are the hardest to create whilst reedbed is the easiest. Had orchard been specifically included in this analysis it would likely have been ranked as the easiest to create.

The potential cost of restoring the degraded habitat has also been assessed. The overall cost for creating and managing 15% priority habitats over a 5 year period (without land-purchase or landowner compensation costs) is estimated to be in the region of between £383 and £541 million corresponding to a total created area of between 117,702 and 175,257 hectares respectively. If land purchase costs are included these figures jump to between £2.4 and £3.5 billion. These are clearly significant sums which do not specifically include the costs of the local studies that would likely be required to support the restoration actions.

A number of project uncertainties have been highlighted and as a result, care will be required in the interpretation of the outputs. Suggestions have been made below for further work that could reduce uncertainty in the outputs.

7.2 Suggestions

A number of suggestions arise from the work undertaken for this study and these are detailed below.

- To address the differences between this project and the Wetland Vision in respect of the distribution of groundwater fed fens, it is suggested that further development of the Outcome 1D model derived through this project could be undertaken to incorporate hydrogeological information. However, given the very large extent of fen potential habitat defined by the Wetland Vision, it is recommended that a similar but amended approach should be developed to ensure that potential for base rich groundwater fed fens and base poor groundwater fed fens are accounted for in the analysis, without over-representing the potential extent possible;

- The imminent release of the single layer BAP habitat inventory may result in changes to the areas that are clipped from the dataset at the outset, and hence the areas of potential identified. The model could be amended to include the single BAP layer instead of the many different layers that were used in this project;

- The model could be developed to take account of climate change insofar as there will be areas of potential habitat that are subsequently lost to coastal erosion, sea level rise etc. It may be possible to include these considerations such that areas are not targeted where these additional pressures are likely. Reference could be made to the Entec (2011) and the Environment Agency Shoreline Management Plans to inform this development;

- Using the GIS project supplied with this project Natural England's GIS experts could use the individual metrics (e.g. the proximity to biodiversity metric) to target specific areas or regions for restoration action. Additionally, the weightings applied to each of the metrics could be altered to place greater weight on one metric compared to another. In this project to date an equal weighting has been applied to each of the metrics. However, it is possible that current or future policy or climate change drivers may elevate the importance of one or more metrics over others in which case re-analysis applying different weighting may be desirable/ beneficial;

- If Natural England wanted to focus efforts on orchards specifically a comparison could be made, using the GIS data collated during this project, of the distribution of orchards as represented in the Dudley Stamp dataset with the current orchard BAP habitat inventory. This would highlight areas of lost habitat that could be targeted directly;

- The project or approach could be developed further, to assess the value of the habitats in respect of wider ecosystem services e.g. provisioning or supporting services, in addition to those implicitly covered by the metrics already developed in this project.

8. References

Alonso, I., Weston, K., Gregg, R. & Morecroft, M. (2012). *Carbon Storage by Habitat - Review of the Evidence of the Impacts of Management Decisions and Condition on Carbon Stores and Sources*. Natural England Research Reports, Number NERR043.

Anon. (2010). *Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Tenth Meeting: COP10 X/2 The Global Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets*. Decision by the Conference of the Parties. Available at http://www.cbd.int/sp/default.shtml

Arcadis (2013). *Implementation of 2020 EU Biodiversity Strategy: Priorities for the Restoration of Ecosystems and their Services in the EU: Concept Paper V2.* Report to the European Commission.

Biodiversity Reporting and Information Group (BRIG) (2008, Updated 2011). *UK Biodiversity Action Plan Priority Habitat Descriptions.*

Burns F., Eaton M.A., Gregory R.D., (2013). *State of Nature Report*. The State of Nature Partnership.

Dargie, T.C. (*1993*). *The Distribution of Lowland Wet Grassland in England. Research Report 49. English Nature, Peterborough.*

Defra (2010). *Delivering a Healthy Natural Environment: An update to 'Securing a Healthy Natural Environment: An Action plan for Embedding an Ecosystems Approach*". Defra, London.

Defra (2011). *Biodiversity 2020: A Strategy for England's Wildlife and Ecosystem Services*. Defra, London.

Entec (2010). GIS Classification of the 1930-1940's Land Utilisation Survey (LUS). Report for Environment Agency.

Entec (2011). *Developing Tools to Evaluate the Consequences for Biodiversity of Options for Coastal Zone Adaptation to Climate Change (CR0422)*. Report to Defra.

European Commission (2011). *Communication from the Commission to the European Parliament, The Council, The Economic and Social Committee and the Committee of the Regions. Our Life Insurance, Our Natural Capital: An EU Biodiversity Strategy to 2020*. *COM (2011) 244 Final*. Available at: http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm.

European Commission (2013). *Mapping and Assessment of Ecosystems and their Services. An Analytical Framework for Ecosystem Assessments under Action 5 of the EU Biodiversity Strategy to 2020*. Technical Report 2013-067.

GHK Consulting Ltd (2006). *UK Biodiversity Action Plan: Preparing Costings for Species and Habitat Action: Costings Summary Report*. Revised Report to Defra and Partners.

Holliday, K. (2008). *Developing Priority Maps for the England Wetland Vision. Wetland Vision Technical Document: Overview and Reporting of Project Philosophy and Approach*. Report for the Wetland Vision Partnership.

Hume, C. (2008). *Wetland Vision Technical Document: Overview and Reporting of Project Philosophy and Technical Approach*. The Wetland Vision Partnership.

HM Government (2011). *The Natural Choice – Securing the Value of Nature*. White Paper presented to Parliament by the Secretary of State for Environment, Food and Rural Affairs.

Natural England (2009). *Agri-environment Schemes in England 2009: A Review of Results and Effectiveness.* NE194. Natural England, Peterborough.

Natural England (2010). *England's Peatlands – Carbon Storage and Greenhouse Gases. Natural England Research Report 257*. Natural England, Peterborough.

Natural England (2012). Environmental Stewardship and Climate Change Mitigation. NE TIN109.

Lawton, J. (2010). *Making Space for Nature – A Review of England's Wildlife Sites and Ecological Network*: Report to Defra.

Milne, R. And Brown, T.A. (1997). Carbon in the Vegetation and Soils of Great Britain. *Journal of Environmental Management* No. **49**, 413–433.

Painter, M., Smith, K. and Gilbert, G. (1995). *An Inventory of British Reedbeds 1993*. RSPB, London.

Taylor, S. and Knight, M. (2013). National biodiversity climate change vulnerability model. Draft report for Natural England.

University of Hertfordshire (2011). *A revisit to previous research into the current and potential climate change mitigation effects of environmental stewardship* (BD5007).

Waters, R. (2012). *Task and Finish Group 3 – Report*. Technical Report for the Terrestrial Biodiversity Group, Natural England.

Wheeler, B.D., Shaw, S. and Tanner, K. (2009). *A Wetland Framework for Impact Assessment at Statutory Sites in England and Wales. Science Report: SC030232/SR1.* Environment Agency, Bristol.

Wheeler, B.D., Shaw, S.C., Brooks, A. and Whiteman, M. (2010). *Protecting the Plant Communities and Rare Species of Fen and Mire Wetland Systems: Ecohydrological Guidelines for Lowland Wetland Plant Communities Fens and Mires Update*. Environment Agency, Bristol.

Worrall, F., Chapman, P., Holden, J., Evans, C., Artz, R., Smith, P. & Grayson, R. (2011) *A Review of Current Evidence on Carbon Fluxes and Greenhouse Gas Emissions from UK Peatland*. JNCC Report, No. 442. JNCC, Peterborough.

Appendix A
Geoprocessing Models for the Identification of Baseline Areas of Potential

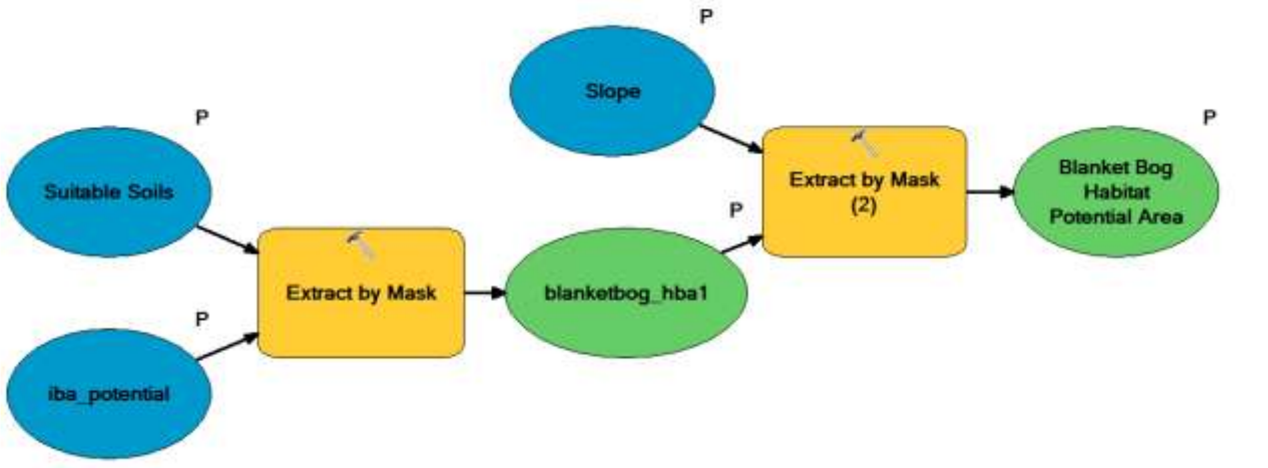


Plate A1 Geoprocessing Model for the Identification of Baseline Area of Potential for Blanket Bog

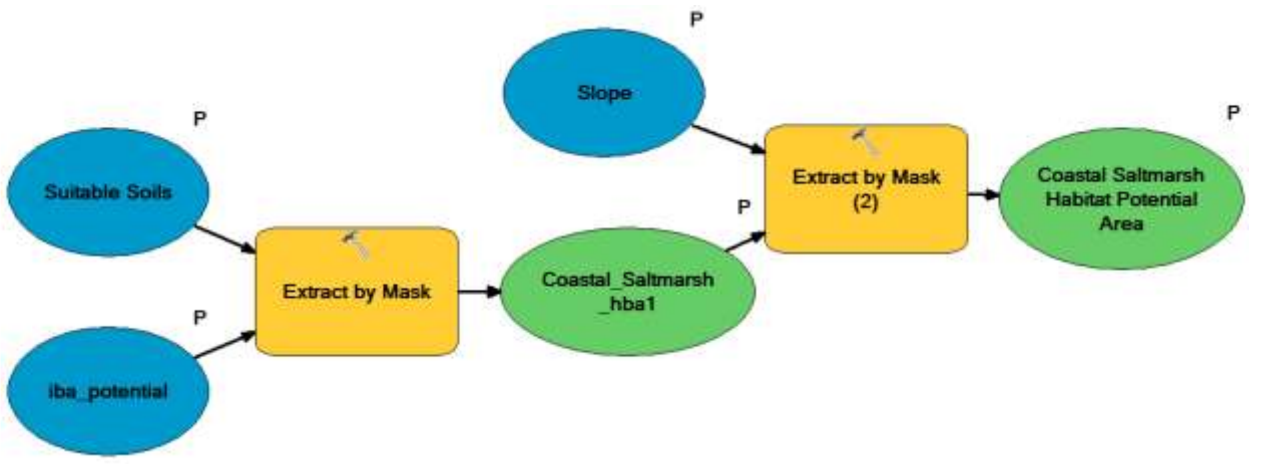


Plate A2 Geoprocessing Model for the Identification of Baseline Area of Potential for Coastal Saltmarsh

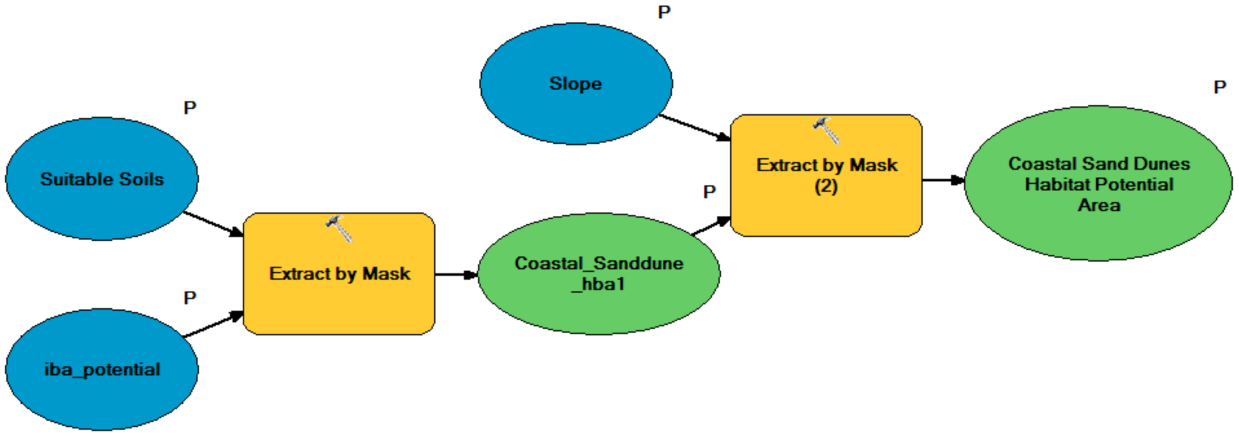


Plate A3 **Geoprocessing Model for the Identification of Baseline Area of Potential for Coastal Sand Dunes**

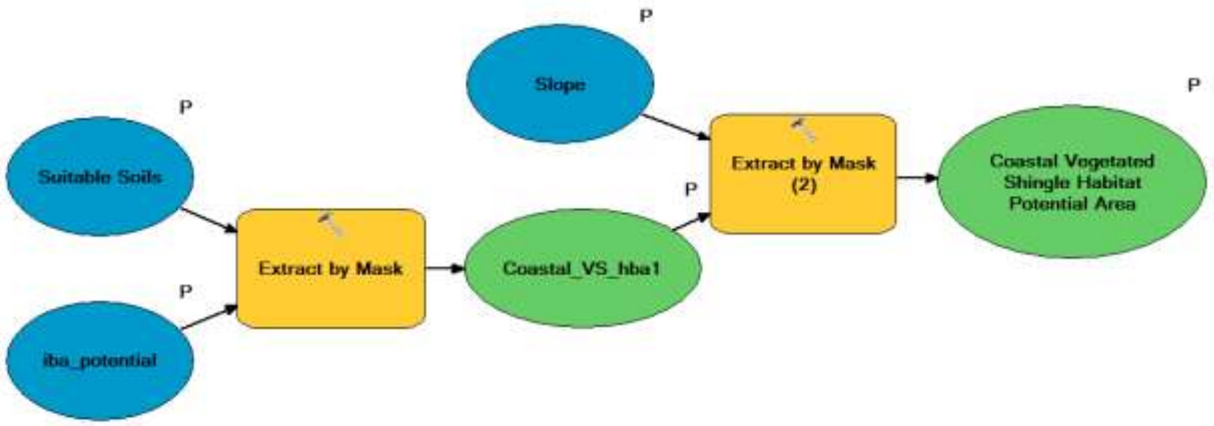


Plate A4 **Geoprocessing Model for the Identification of Baseline Area of Potential for Coastal Vegetated Shingle**

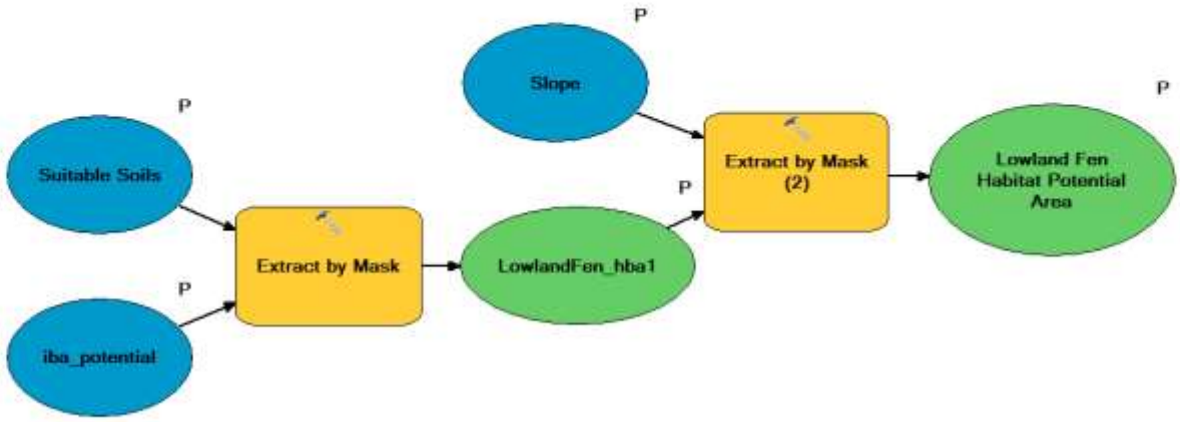


Plate A5 Geoprocessing Model for the Identification of Baseline Area of Potential for Lowland Fen

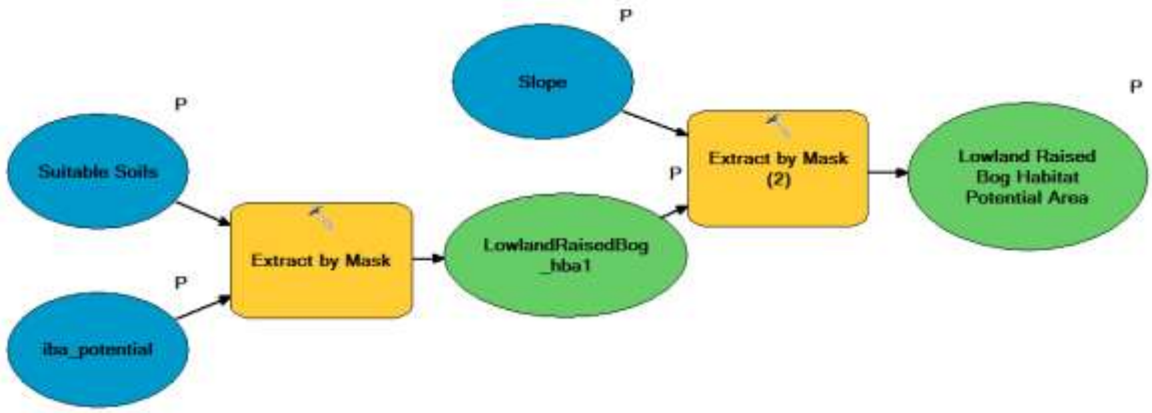


Plate A6 Geoprocessing Model for the Identification of Baseline Area of Potential for Lowland Raised Bog

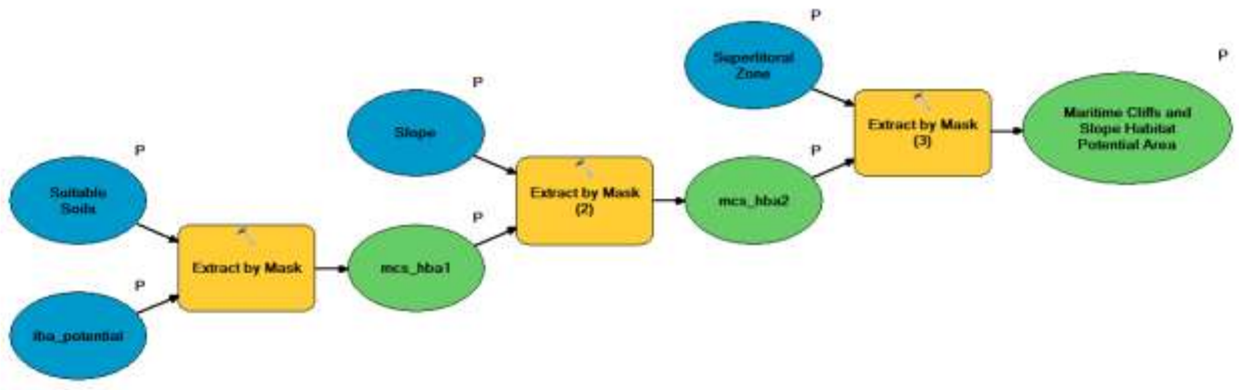


Plate A7 Geoprocessing Model for the Identification of Baseline Area of Potential for Maritime Cliffs and Slope

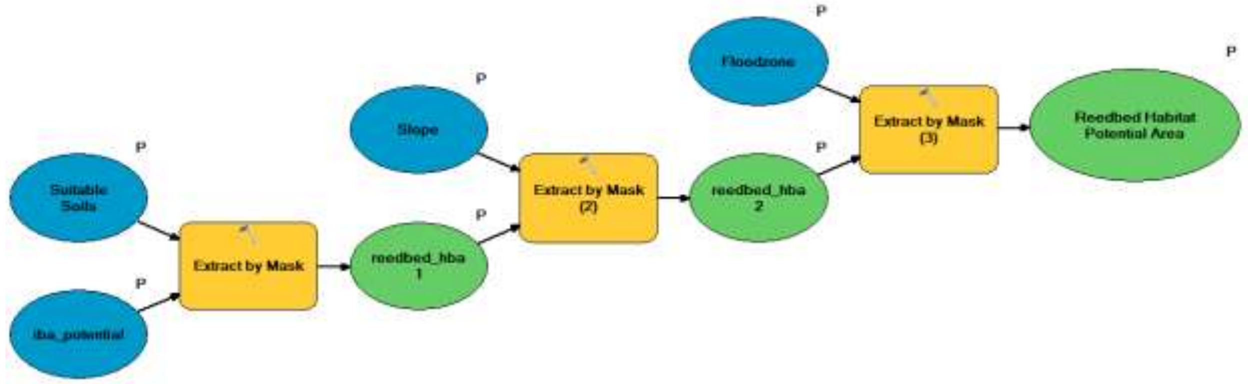


Plate A8 Geoprocessing Model for the Identification of Baseline Area of Potential for Reedbed

Appendix B
Land Use Change Combinations

Former Dudley Stamp Land Cover Class Present	Corresponding CEH Land Cover Class 2007 now Present	If LC class this then considered lost, same or different but still potentially of value
Heath and Moorland	Unclassified	Lost
Heath and Moorland	Broadleaved, mixed and yew woodland	Different
Heath and Moorland	Coniferous woodland	Different
Heath and Moorland	Arable and horticulture	Lost
Heath and Moorland	Improved grassland	Lost
Heath and Moorland	Rough grassland	Different
Heath and Moorland	Neutral grassland	Different
Heath and Moorland	Calcareous grassland	Different
Heath and Moorland	Acid grassland	Different
Heath and Moorland	Fen, marsh and swamp	Same
Heath and Moorland	Heather	Same
Heath and Moorland	Heather grassland	Same
Heath and Moorland	Bog	Same
Heath and Moorland	Montane habitats	Same
Heath and Moorland	Inland rock	Same
Heath and Moorland	Saltwater	Lost
Heath and Moorland	Freshwater	Different
Heath and Moorland	Supra-littoral rock	Lost
Heath and Moorland	Supra-littoral sediment	Lost
Heath and Moorland	Littoral rock	Lost
Heath and Moorland	Littoral sediment	Lost
Heath and Moorland	Saltmarsh	Different
Heath and Moorland	Urban	Lost
Heath and Moorland	Suburban	Lost
Urban	Unclassified	N/A
Urban	Broadleaved, mixed and yew woodland	N/A
Urban	Coniferous woodland	N/A
Urban	Arable and horticulture	N/A
Urban	Improved grassland	N/A
Urban	Rough grassland	N/A
Urban	Neutral grassland	N/A
Urban	Calcareous grassland	N/A
Urban	Acid grassland	N/A
Urban	Fen, marsh and swamp	N/A
Urban	Heather	N/A
Urban	Heather grassland	N/A
Urban	Bog	N/A
Urban	Montane habitats	N/A
Urban	Inland rock	N/A
Urban	Saltwater	N/A
Urban	Freshwater	N/A
Urban	Supra-littoral rock	N/A
Urban	Supra-littoral sediment	N/A
Urban	Littoral rock	N/A
Urban	Littoral sediment	N/A
Urban	Saltmarsh	N/A
Urban	Urban	N/A
Urban	Suburban	N/A

Former Dudley Stamp Land Cover Class Present	Corresponding CEH Land Cover Class 2007 now Present	If LC class this then considered lost, same or different but still potentially of value
Water	Unclassified	Lost
Water	Broadleaved, mixed and yew woodland	Different
Water	Coniferous woodland	Different
Water	Arable and horticulture	Lost
Water	Improved grassland	Lost
Water	Rough grassland	Different
Water	Neutral grassland	Different
Water	Calcareous grassland	Different
Water	Acid grassland	Different
Water	Fen, marsh and swamp	Same
Water	Heather	Different
Water	Heather grassland	Different
Water	Bog	Different
Water	Montane habitats	Different
Water	Inland rock	Lost
Water	Saltwater	Lost
Water	Freshwater	same
Water	Supra-littoral rock	Lost
Water	Supra-littoral sediment	Lost
Water	Littoral rock	Lost
Water	Littoral sediment	Lost
Water	Saltmarsh	Lost
Water	Urban	Lost
Water	Suburban	Lost
Arable	Unclassified	Lost
Arable	Broadleaved, mixed and yew woodland	Different
Arable	Coniferous woodland	Different
Arable	Arable and horticulture	Same
Arable	Improved grassland	Same
Arable	Rough grassland	Different
Arable	Neutral grassland	Different
Arable	Calcareous grassland	Different
Arable	Acid grassland	Different
Arable	Fen, marsh and swamp	Different
Arable	Heather	Different
Arable	Heather grassland	Different
Arable	Bog	Different
Arable	Montane habitats	Different
Arable	Inland rock	Lost
Arable	Saltwater	Lost
Arable	Freshwater	Different
Arable	Supra-littoral rock	Lost
Arable	Supra-littoral sediment	Lost
Arable	Littoral rock	Lost
Arable	Littoral sediment	Lost
Arable	Saltmarsh	Different
Arable	Urban	Lost
Arable	Suburban	N/A

Former Dudley Stamp Land Cover Class Present	Corresponding CEH Land Cover Class 2007 now Present	If LC class this then considered lost, same or different but still potentially of value
Suburban	Unclassified	N/A
Suburban	Broadleaved, mixed and yew woodland	N/A
Suburban	Coniferous woodland	N/A
Suburban	Arable and horticulture	N/A
Suburban	Improved grassland	N/A
Suburban	Rough grassland	N/A
Suburban	Neutral grassland	N/A
Suburban	Calcareous grassland	N/A
Suburban	Acid grassland	N/A
Suburban	Fen, marsh and swamp	N/A
Suburban	Heather	N/A
Suburban	Heather grassland	N/A
Suburban	Bog	N/A
Suburban	Montane habitats	N/A
Suburban	Inland rock	N/A
Suburban	Saltwater	N/A
Suburban	Freshwater	N/A
Suburban	Supra-littoral rock	N/A
Suburban	Supra-littoral sediment	N/A
Suburban	Littoral rock	N/A
Suburban	Littoral sediment	N/A
Suburban	Saltmarsh	N/A
Suburban	Urban	N/A
Suburban	Suburban	N/A
Meadow and Grass	Unclassified	Lost
Meadow and Grass	Broadleaved, mixed and yew woodland	Different
Meadow and Grass	Coniferous woodland	Different
Meadow and Grass	Arable and horticulture	Lost
Meadow and Grass	Improved grassland	Lost
Meadow and Grass	Rough grassland	same
Meadow and Grass	Neutral grassland	same
Meadow and Grass	Calcareous grassland	same
Meadow and Grass	Acid grassland	same
Meadow and Grass	Fen, marsh and swamp	Different
Meadow and Grass	Heather	Different
Meadow and Grass	Heather grassland	Different
Meadow and Grass	Bog	Different
Meadow and Grass	Montane habitats	Different
Meadow and Grass	Inland rock	Lost
Meadow and Grass	Saltwater	Lost
Meadow and Grass	Freshwater	Different
Meadow and Grass	Supra-littoral rock	Lost
Meadow and Grass	Supra-littoral sediment	Lost
Meadow and Grass	Littoral rock	Lost
Meadow and Grass	Littoral sediment	Lost
Meadow and Grass	Saltmarsh	Different
Meadow and Grass	Urban	Lost
Meadow and Grass	Suburban	Lost

Former Dudley Stamp Land Cover Class Present	Corresponding CEH Land Cover Class 2007 now Present	If LC class this then considered lost, same or different but still potentially of value
Forest and Woodland	Unclassified	Lost
Forest and Woodland	Broadleaved, mixed and yew woodland	Same
Forest and Woodland	Coniferous woodland	Same
Forest and Woodland	Arable and horticulture	Lost
Forest and Woodland	Improved grassland	Lost
Forest and Woodland	Rough grassland	Different
Forest and Woodland	Neutral grassland	Different
Forest and Woodland	Calcareous grassland	Different
Forest and Woodland	Acid grassland	Different
Forest and Woodland	Fen, marsh and swamp	Different
Forest and Woodland	Heather	Different
Forest and Woodland	Heather grassland	Different
Forest and Woodland	Bog	Different
Forest and Woodland	Montane habitats	Different
Forest and Woodland	Inland rock	Lost
Forest and Woodland	Saltwater	Lost
Forest and Woodland	Freshwater	Different
Forest and Woodland	Supra-littoral rock	Lost
Forest and Woodland	Supra-littoral sediment	Lost
Forest and Woodland	Littoral rock	Lost
Forest and Woodland	Littoral sediment	Lost
Forest and Woodland	Saltmarsh	Different
Forest and Woodland	Urban	Lost
Forest and Woodland	Suburban	Lost
Orchard	Traditional Orchard BAP inventory Map (compare this first)	Same
	Then cut directly comparable habitat out and analyse rest as different or lost	
Orchard	Unclassified	
Orchard	Broadleaved, mixed and yew woodland	Different
Orchard	Coniferous woodland	Lost
Orchard	Arable and horticulture	Lost
Orchard	Improved grassland	Lost
Orchard	Rough grassland	Different
Orchard	Neutral grassland	Different
Orchard	Calcareous grassland	Different
Orchard	Acid grassland	Different
Orchard	Fen, marsh and swamp	Different
Orchard	Heather	Different
Orchard	Heather grassland	Different
Orchard	Bog	Different
Orchard	Inland rock	Lost
Orchard	Saltwater	Lost
Orchard	Freshwater	Different
Orchard	Supra-littoral rock	Lost
Orchard	Supra-littoral sediment	Lost
Orchard	Littoral rock	Lost
Orchard	Littoral sediment	Lost
Orchard	Saltmarsh	Different
Orchard	Urban	Lost
Orchard	Suburban	Lost

Appendix C
Geoprocessing Models for the Metrics

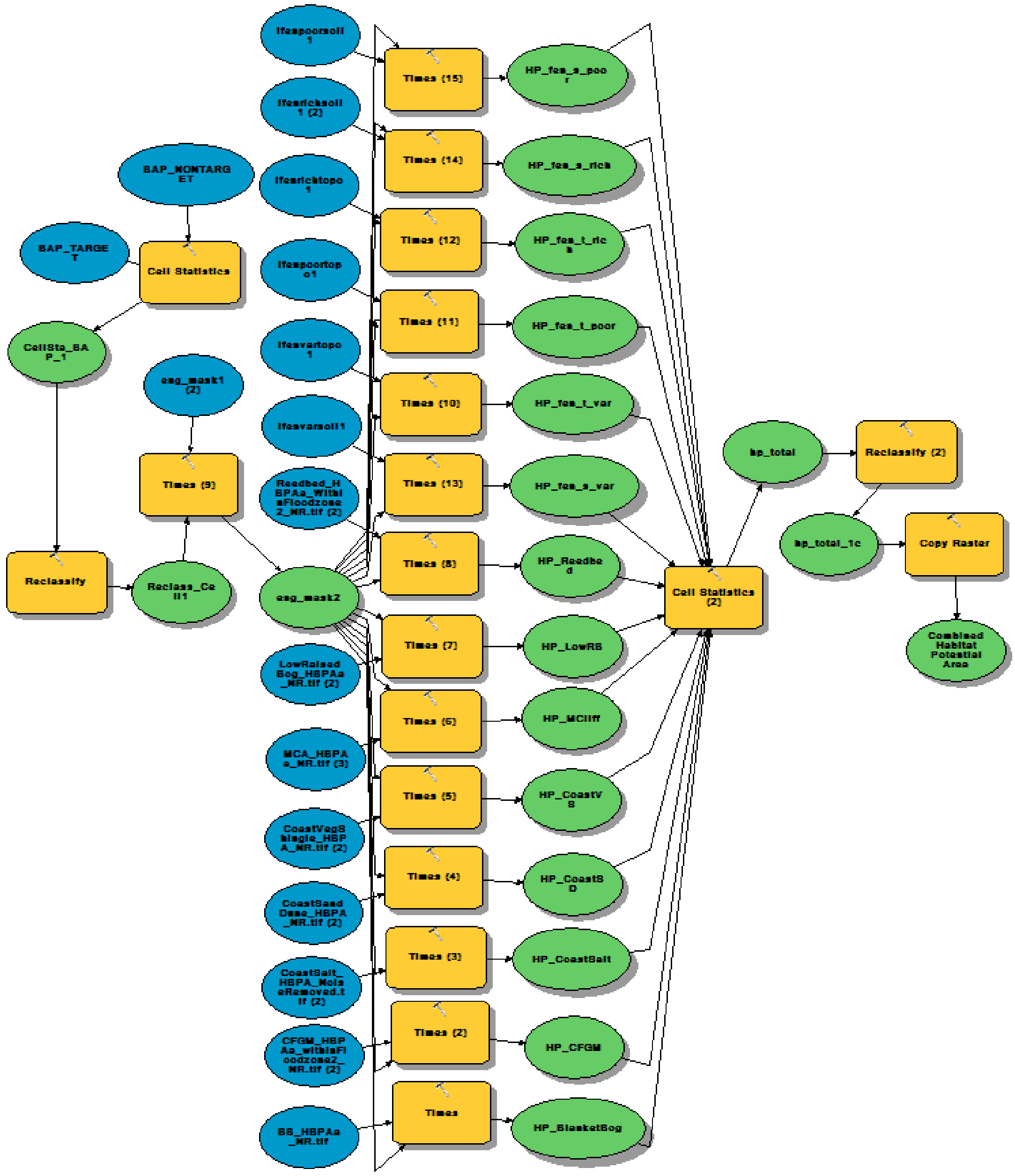


Plate C1 Geoprocessing Model for the Combination of all 9 Habitat Baseline Areas of Potential

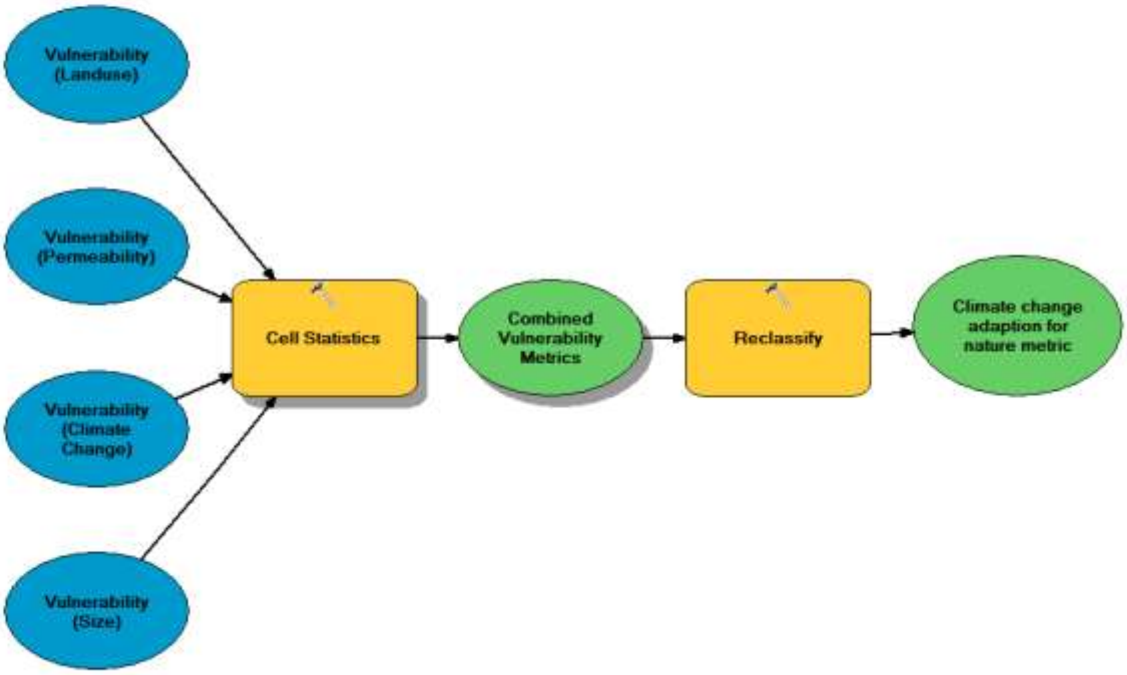


Plate C2 Geoprocessing Model for the Climate Change Adaption for Nature Metric

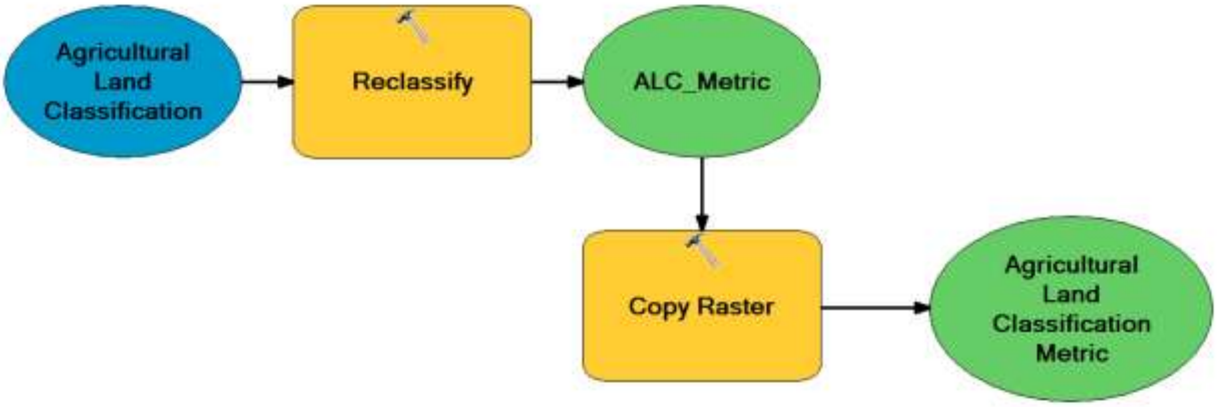


Plate C3 Geoprocessing Model for the Agricultural Land Classification Metric

Plate C4 **Geoprocessing Model for the Climate Change Mitigation (Carbon) Metric**

Appendix D
Ease of Habitat Creation Scoring Approach and Ranking Analysis and Summary Evidence and References Supporting the Scoring Decisions (extract from Entec, 2011)

Table D.1 Criteria and Scoring used to Rank Habitats in Order of Ease of Creation

Parameter	Criteria *In General, Successful Creation….*		Options	Ease of Implementation Scoring (Qualitative)	Ease of Implementation Scoring (Quantitative)
Timescales	…requires the following timescales	A	5-9 years	Achievable on a short (project/management plan) timescale	1
		B	10-50 years	Achievable on a medium (human 'generation') timescale	2
		C	50-100s of years	Achievable in a longer (several human 'generations') timescale	5
Size (ha) (min. extent)	…requires the following minimum area to be ecologically functional	A	<2ha	Achievable with minimum land acquisition	1
		B	2 to 9ha	Achievable with a small amount of land acquisition	2
		C	10-99ha	Achievable with a greater extent of land acquisition	5
Method of creation-recreation	…requires the following method of creation	A	Abandonment of current land use only	Achievable with minimum involvement/intervention	1
		B	Limited land preparation and no/only small-scale engineering/water control	Achievable with a greater level of involvement/engineering	2
		C	Extensive land preparation, significant engineering/water control	Achievable with extensive involvement/engineering	5
Hydrological regime	…requires/tolerates the following hydrological regime	A	Tolerates a highly variable or not particularly exacting water regime year round (e.g. tolerates water table several 10s of centimetres below ground level to occasional inundation. Habitats needing standing water - wide variation acceptable relative to water body depth), groundwater not specifically required	Probably achievable with minimum involvement/intervention/management of regime	1
		B	Able to tolerate less water table variation / requires more exacting regime (e.g. does not require water table at the surface, tolerates water table around 10-20 centimetres below ground level with specific seasonal requirements. Habitats needing standing water - moderate variation in water depth tolerated relative to water body depth), some groundwater input required	Probably achievable with a greater level of involvement/engineering/management of regime	2
		C	Requires an exacting regime where the water table is at or near (within a few centimetres) the ground surface all year. Habitats needing standing water unable to tolerate variation of more than a few cm. Significant groundwater input required to maintain the habitat	Probably requires extensive involvement/engineering/management of regime	5
Trophic status	…requires/tolerates the following trophic status	A	Eutrophic	Requires water sources widely available	1
		B	Eutrophic/mesotrophic	Requires water sources less widely available	2
		C	Mesotrophic	Requires water sources with restricted availability	5
		D	Oligotrophic	Requires water sources with very restricted availability	15
Substrate availability	…requires substrate which	A	Is abundant/widely distributed nationally	Substrate is abundant/widely distributed nationally	1
		B	Generally is less abundant/has a more restricted distribution nationality	Substrate is generally less abundant/has a more restricted distribution nationally	2
		C	Generally is not abundant/ has a localised distribution nationally	Substrate is generally not abundant/ has a localised distribution nationally	5
Source of biological material	…requires the following source of biological material	A	Natural succession	Achievable with minimum involvement/landscaping	1
		B	Initial seeding	Achievable with a greater level of involvement/landscaping	2
		C	Involved extensive planting/seeding	Achievable with extensive involvement/landscaping	5
Management	…requires the following management	A	Low intensity management (every 5 years or greater)	Achievable with minimum involvement/management	1
		B	Moderate intensity management (every 2 years or so)	Achievable with a greater level of involvement/management	2
		C	Continuous/intensive (annual) management	Achievable with extensive involvement/management	3

Table D.2 Results of the Scoring and Ranking Exercise

	Coastal and Floodplain Grazing Marsh		Eutrophic Standing Water (Lakes and Ponds)		Fen		Lowland Raised Bog		Purple Moor Grass and Rush Pasture		Reedbed		Saline Lagoons		Wet Woodland	
	Option	Score	Option	Score	Option	Score	Option	Score	Option	Score	Option	Score	Option r	Score	Option	Score
Timescales	A	1	A	1	B	2	C	5	A	1	A	1	A	1	B	2
Size (ha) (min. extent)	B	2	A	1	C	5	C	5	B	2	B	2	A	1	B	2
Method of creation	B	2	B	2	C	5	C	5	B	2	B	2	B	2	A	1
Hydrological regime	B	2	A	1	C	5	C	5	B	2	A	1	B	2	B	2
Trophic status	B	2	A	1	B	2	D	15	C	5	B	2	C	5	B	2
Substrate availability	A	1	A	1	C	5	C	5	A	1	B	2	A	1	A	1
Source of biological material	B	2	B	2	B	2	B	2	B	2	B	2	A	1	C	5
Management	C	5	A	1	B	2	A	1	C	5	B	2	A	1	A	1
Score		**17**		**10**		**28**		**43**		**20**		**14**		**14**		**16**

All scores are out of a maximum of 50.
Ponds and lakes have not been separated in the scoring exercise. The only difference would be in the score for minimum size, where lakes would have a B (scoring 2).
The ease of creating wet woodland has been assessed despite the use of a composite deciduous woodland BAP inventory in the risk analyses.

Timescales

Habitat	Creation timescales	Ref.	Option	Rationale/comments
Coastal and Floodplain Grazing Marsh	Several years	4	A	Grassland (ditches included in eutrophic standing water) Restored grazing marsh grassland has been created at numerous sites around the English coast, with some success in terms of habitat structure and ability to support wetland birds. The time span required for the lowland wet grassland that forms a component of the grazing marsh landscape may be allocated to Option B **IF** botanically-rich swards are the objective
Eutrophic standing waters	Several years	1 and 3	A	Ponds/ditches (including those within a grazing marsh landscape) Numerous examples both of ditch creation in grazing marshes and of pond creation (*e.g.* http://www.pondconservation.org.uk/) exist, where acceptable results have been created in <10 years
Fen	Several decades		B	Some variants of fen habitat may be created in a relatively short time, especially where the fen is essentially a modified reedbed with a larger forb component or where lowland wet grassland is subject to less frequent cutting and grazing. However, for more complex fen habitats with peat development, the evidence from sites such as the Great Fen and the Wicken Vision is that a period of at least a decade is necessary to give any semblance of true fen (see lowland raised bog)
Lowland raised bog	At least several decades	5	C	Based upon experience at Thorne and Hatfield Palaeoecological evidence and natural recolonisation of cutover raised bogs (*e.g.* within the Brue valley of Somerset) shows that lowland raised bogs frequently develop through an intermediate seral stage of fen, consistent with allocation of the fen and bog to timescale options B and C respectively
Purple moor grass and rush pasture	Several years	1, 6, 7	A	Rush pasture/fen created at landfill site Other examples of creating *Molinia-Juncus* habitat suggest some-what longer timescales, especially where the measure of success in comparison with high-grade habitat (*e.g.* NVC type **M24**)
Reedbed	Several years	8, 9, 10	A	Reed grows rapidly Numerous examples of reed-bed creation in shallow lagoons, abandoned peat-diggings *etc*. Some experimental work using either rhizome fragments or from seed. See sources and also http://www.rspb.org.uk/ourwork/conservation/managingreserves/habitats/reedbeds/reedbedcreation.asp
Saline lagoons	Several years		A	
Wet woodland	5-13 years to establish	1, 11	B	May take up to 40 years if rely on natural succession

References

1 Ecoscope Applied Ecologists (2000) Wildlife Management and Habitat Creation on Landfill Sites
2 Pers.comms with Tim Kohler Natural England
3 Gilbert and Anderson (1998) Habitat Creation and Repair
4 Parker (1995) Habitat Creation a Critical Guide
5 Sutherland and Hill (2005) Managing Habitats for Conservation
6 Adams, W.A., Roughley, G., Young, R.J., (1999). An experimental study to re-establish Molinia–Juncus pasture from improved grassland at Rhos Llawr-cwrt National Nature Reserve. Countryside Council for Wales Contract Science Report No. 355, Bangor.
7 Tallowin, J.R.B., Smith, R.E.N., 2001. Restoration of a *Cirsio–Molinietum* fen-meadow on an agriculturally improved pasture. *Restoration Ecology* **9,** 167–178.
8 Fermor, P.M., Hedges, P.D., Gilbert, J.C. and Gowing, D.J.G. (2001). Reedbed evapo-transpiration rates in England. *Hydrological Processes*, **15:** 621-631
9 Gilman, K., Hudson, J.A. and Crane, S.B. (1998). *Hydrological evaluation of reedbed re-creation at Ham Wall Somerset.* Report to Somerset County Council, RSPB & English Nature. EU Life Project 92-1/UK/026
10 Hawke, C.J. and José, P.V. (1996). *Reedbed management for commercial and wildlife interests*. Sandy: Royal Society for the Protection of Birds.
11 R., Gonzáles del Tánago, M., and Mountford, J.O. (In press). Restoring floodplain forests in Europe. Book chapter (#18) in: In P. Madsen, P., Stanturf, J. (eds.). *A Goal-Oriented Approach to Forest Landscape Restoration.* Springer

Size

Habitat	Min. creation size	Ref.	Option	Rationale/comments
Coastal and Floodplain Grazing Marsh	2-5 ha	2	B	To support wetland birds Smaller areas might be viable for vegetation and invertebrates
Eutrophic standing waters	$100m^2$	1	A	Minimum size for great crested newt Again smaller areas may be viable for vegetation and invertebrates, and less mobile vertebrates (*e.g*. smaller fish)
Fen	Tens to hundreds of hectares	4, 5	C	Estimation of area required based upon tall-herb rich fen (*NVC* types S24 *etc*) - the main type of this habitat in landscapes vulnerable to saline floods. Where the fen supports or is intended to support "landscape species" (ref. 5) then larger areas of habitat should be considered as the minimum viable
Lowland raised bog	Tens to hundreds of hectares	6	C	Viable areas of raised mire may be as little as 1 ha in extent but only where buffered by larger areas of degraded habitat and isolated/distinct areas of raised mire are normally well in excess of 50 ha
Purple moor grass and rush pasture	Several hectares		B	Individual fields of this habitat may be as small as 2 ha extent, but tend to occur in complexes were several adjacent fields support this habitat
Reedbed	At least 2 ha	2 and 3	B	20 ha to support bittern *et al* Since the primary conservation value of this habitat lies with the animals (especially vertebrates) that it supports, estimates of minimum creation size for reedbed should be based on the requirements of such "landscape species"
Saline lagoons	<2ha		A	
Wet woodland	at least 5 ha	1	B	Although areas as small as 1 ha are defined as woodland under agri-environment schemes, the functional habitat (together with its characteristic vertebrates) requires a bare minimum of 5 ha

References

1 Ecoscope Applied Ecologists (2000) Wildlife Management and Habitat Creation on Landfill Sites

2 Parker (1995) Habitat Creation a Critical Guide

3 Sutherland and Hill (2005) Managing Habitats for Conservation

4 WCS (2001) The Landscape species approach- a tool for site-based conservation. *Wildlife Conservation Society Living Landscapes Program Bulletin* 2: 1-4.

5 Hughes, F.M.R., Stroh, P., Mountford, J.O., Warrington, S., Gerrard, C. & Jose, P. (2008) Monitoring large-scale wetland restoration projects: Is there an end in sight? in P. Carey (ed.) Landscape Ecology and Conservation. Proceedings of the 15th Annual Conference of the International Association for Landscape Ecology (UK Chapter), Cambridge, UK, September 8-11th , 2008 p.170-179.

6 Bragg, O.M., Lindsay, R.A., Robertson *et al* (1984). *An historical survey of lowland raised mires, Great Britain.* Nature Conservancy Council

Creation Method

Habitat	Creation Method	Ref.	Option	Rationale/comments
Coastal and Floodplain Grazing Marsh		1, 3, 4	B	Likely for some preparation to be needed (*e.g.* appropriate seed mix, irregular topography, some water control)
Eutrophic standing waters		1	B	Hole needs to be dug for water body or ditch as a minimum
Fen		2, 5	C	As for bog
Lowland raised bog	Very involved	2	C	Based upon re-wetting of lowland raised bog at Thorne & Hatfield (pers.comms Tim Kohler Natural England)
Purple moor grass and rush pasture			B	Natural successional process following abandonment is for habitat to become more rank. Some land preparation and seeding likely to be needed
Reedbed		1	B	Reed will readily colonise unaided if right conditions persist and reed is already present. However some ground preparation and plug planting likely to be necessary. Hence option B selected.
Saline lagoons		1	B	Hole needs to be dug for lagoon as a minimum
Wet woodland		1	A	Natural successional process following abandonment is for habitat to scrub over

References

1 Gilbert and Anderson (1998) Habitat Creation and Repair
2 Parker (1995) Habitat Creation a Critical Guide
3 Benstead, P., Drake, M, José, P, Mountford, O., Newbold, C. and Treweek, J. 1997. *The Wet Grassland Guide.* Sandy: Royal Society for the Protection of Birds.
4 Manchester, S.J (Unpublished). The potential for the restoration of lowland wet grassland upon ex-arable land. Unpublished Ph.D. thesis, Oxford Brookes University, Oxford.
5 McBride, A., Diack, I., Droy, N., Hamill, B., Jones, P., Schutten, J., Skinner, A. and Street, M. (2010). *The Fen Management Handbook.* Scottish Natural Heritage. Perth [see Chapter 9 on Creating Fen Habitat]

Hydrology

Habitat	Regime	Ref.	Option
Coastal and Floodplain Grazing Marsh	MG8 tolerates summer water table several tens of centimetres below ground and occasional inundation	1	B
Eutrophic standing waters	Typically composed of free floating species able to tolerate fluctuations, and even temporary drying out provided substrate remains damp	1	A
Fen	S24e supports most rare species and requires water table at or near surface most of the year	1	C
Lowland raised bog	Pristine bogs have a water table at or near the surface	4	C
Purple moor grass and rush pasture	M24 tolerates summer water table several tens of centimetres below ground and occasional inundation	1	B
Reedbed	S4 tolerates a regime from 0.5m agl to 0.15 bgl	1	A
Saline lagoons	Able to tolerate a reasonable amount of fluctuation in water levels provided salinity ranges are maintained	3	B
Wet woodland	Other S24 communities tolerates summer water table several tens of centimetres below ground and occasional inundation	1	B

References

1 Wheeler et al (2004) Ecohydrological Guidelines for Lowland Wetland Plant Communities
2 Barsoum et al (2005) Ecohydrological Guidelines for Wet Woodland - Phase 1
3 Bamber et al (2001) Saline Lagoons: A Guide to Their Management and Creation
4 Stoneman and Brooks (1997) Conserving Bogs The Management Handbook

Notes

Swamp (S24) communities used as surrogates for fen communities based upon workshop outcomes
Fen used as surrogate for wet woodland because the main interest with wet woodland is the ground flora which resembles swamp/fen
Barsoum *et al* - no readily usable quantitative evidence

Trophic Requirements

Habitat	Trophic status	Ref.	Option	Rationale/comments
Coastal and Floodplain Grazing Marsh	Mesotrophic		B &/or C	Option depends on the grassland type - **MG8** is more C than B (which would be appropriate for **MG13, MG11** and other grazing marsh swards)
Eutrophic standing waters	Mesotrophic to eutrophic	1	A	
Fen	S24 communities - mesotrophic to eutrophic	1, 5	B	
Lowland raised bog	Oligotrophic	4	D	
Purple moor grass and rush pasture	**M24** - oligotrophic to mesotrophic	1	C	
Reedbed	**S4** occurs in oligotrophic to eutrophic conditions	1	B	B as a compromise
Saline lagoons	Eutrophication is a threat	3	C	
Wet woodland	S24 communities - mesotrophic to eutrophic	1	B	

References

1 Wheeler et al (2004) Ecohydrological Guidelines for Lowland Wetland Plant Communities
2 Barsoum et al (2005) Ecohydrological Guidelines for Wet Woodland - Phase 1
3 Bamber et al (2001) Saline Lagoons: A Guide to Their Management and Creation
4 Stoneman and Brooks (1997) Conserving Bogs The Management Handbook
5 McBride, A., Diack, I., Droy, N., Hamill, B., Jones, P., Schutten, J., Skinner, A. and Street, M. (2010). *The Fen Management Handbook.* Scottish Natural Heritage. Perth [see Chapter 9 on Creating Fen Habitat]

Notes

Swamp (S24) communities used as surrogates for fen communities based upon workshop outcomes
Fen used as surrogate for wet woodland because the main interest with wet woodland is the ground flora which resembles swamp/fen
Barsoum et al - no readily usable quantitative evidence

Substrate Requirements

Soilscape	National Coverage (England) (%)	Texture	Habitats	Corresponding UK BAP Habitat	Rationale
Water	0.4	-	-	-	
Sub-total	**0.4**				
Lime rich loams and clays impeded	5.3	Clayey	Base rich pasture and ancient woodlands, lime rich flush vegetation in wetter areas	Fen, grazing marsh, rush pasture, wet woodland, reedbed	
Sub-total	**5.3**				
Saltmarsh soils	0.2	Loamy	Coastal salt marsh	-	Saltmarsh not within the scope of the study
Shallow lime rich soils over chalk or	7	Loamy	Limestone pastures, pavements and lime rich deciduous woodlands	Grazing marsh, rush pasture	
Freely draining lime rich loamy soils	3.7	Loamy	Limestone pastures, and lime rich deciduous woodlands	?	Free draining would infer that terrestrialised wetland habitat would not prevail
Freely draining slightly acid loamy so	15.5	Loamy	Neutral and acid pastures, bracken, gorse, deciduous woodlands	-	Free draining would infer that terrestrialised wetland habitat would not prevail
Freely draining slightly acid but base	3.1	Loamy	Base rich pasture and deciduous woodlands	?	Free draining would infer that terrestrialised wetland habitat would not prevail
Slightly acid loams and clays impede	10.6	Loamy	Wide range of pastures and woodlands	Grazing marsh, rush pasture, wet woodland, reedbed	
Freely draining floodplain soils	0.6	Loamy	Grassland and wet carr in old river meanders	Grazing marsh, rush pasture, wet woodland, reedbed	
Freely draining acid loamy soils over	2.6	Loamy	Steep upland acid pastures, dry heath and moor, bracken, gorse and oak woodland	-	Free draining would infer that terrestrialised wetland habitat would not prevail, and upland areas are not within the scope of the study
Slow permeable seasonally wet acid	7	Loamy	Seasonally wet pastures and woodlands	Grazing marsh, rush pasture, wet woodland	
Slow permeable seasonally wet basi	19.9	Loamy	Seasonally wet pastures and woodlands	Grazing marsh, rush pasture, wet woodland	
Naturally wet loamy and clayey flooc	2.6	Loamy	Wet meadows and wet carr in old river meanders	Grazing marsh, rush pasture, wet woodland, reedbed	
Naturally wet loamy and clayey soils	3.7	Loamy	Wet brackish coastal flooded meadows	Grazing marsh, rush pasture	
Naturally wet loamy soils	1.7	Loamy	Wet acid meadows and woodlands	-	These habitats are not within the scope of the study
Restored soils mostly from quarry or	0.4	Loamy	Variable	-	These habitats are not within the scope of the study
Sub-total	**78.6**				
Shallow very acid peaty soils over rc	0.4	Peaty	Wet heather, grass moor, bog	Lowland raised bog	
Very acid loamy upland soils wet pea	1.6	Peaty	Grass moor and heather moor, flush and bog	-	Upland areas not within the scope of the study
Peaty slowly permeable wet very aci	2.9	Peaty	Grass moor and heather moor, flush and bog	-	Upland areas not within the scope of the study
Naturally wet peaty loamy and sandy	1.5	Peaty	Wet meadows	Grazing marsh, rush pasture	
Blanket bog peat soils	2.1	Peaty	Wet heather moor with flush and bog	-	This habitat is not within the scope of the study
Raised bog peat soils	0.3	Peaty	Raised bog	Lowland raised bog	
Fen peat soils	0.7	Peaty	Wet fen and carr	Fen, wet woodland, reedbed	
Sub-total	**9.5**				
Sand dune soils	0.2	Sandy	Sand dune vegetation	-	This habitat is not within the scope of the study

Freely draining slightly acid sandy sc	2.8	Sandy	Acid dry pastures, acid deciduous and coniferous woodland, lowland dry heath	-	Free draining would infer that terrestrialised wetland habitat would not prevail
Freely draining slightly acid Brecklar	0.3	Sandy	Breckland heathland	-	Free draining would infer that terrestrialised wetland habitat would not prevail
Freely draining very acid sandy and	1	Sandy	Lowland dry heath	-	Free draining would infer that terrestrialised wetland habitat would not prevail
Naturally wet very acid sandy and lo	1.9	Sandy	Mixed dry and wet lowland heath	-	This habitat is not within the scope of the study
Sub-total	**6.2**				
TOTALS	100				

Notes
Data taken from National Soil Research Institute at Cranfield University http://www.landis.org.uk/soilscapes/
It is assumed that texture is a surrogate for a 'high-level' categorisation of the various soil types
Reedbed habitat is not mentioned in the Cranfield data and therefore reedbed has been allocated to soil types where wet woodland or fen may occur on peats, clay soils wi
Caveat - the data is a national view not a coastal view

	% of England soil resource available for the habitat
Coastal and Floodplain Grazing Mar	58.2
Fen	6
Lowland raised bog	0.7
Molinia meadows and rush pasture	58.2
Reedbed	19.8
Wet woodland	46.7
Eutrophic standing waters	N/A*
Saline lagoons	N/A*

N/A*: Substrate is not critical as artificial materials could be used

		Rank	Creatibility category
Coastal and Floodplain Grazing Mar	58.2	1	A
Eutrophic standing waters	N/A*	1	A
Fen	6.0	4	C
Lowland raised bog	0.7	5	C
Purple moor grass and rush pasture	58.2	1	A
Reedbed	19.8	3	B
Saline lagoons	N/A*	1	A
Wet woodland	46.7	2	A

Source of Biological Materials

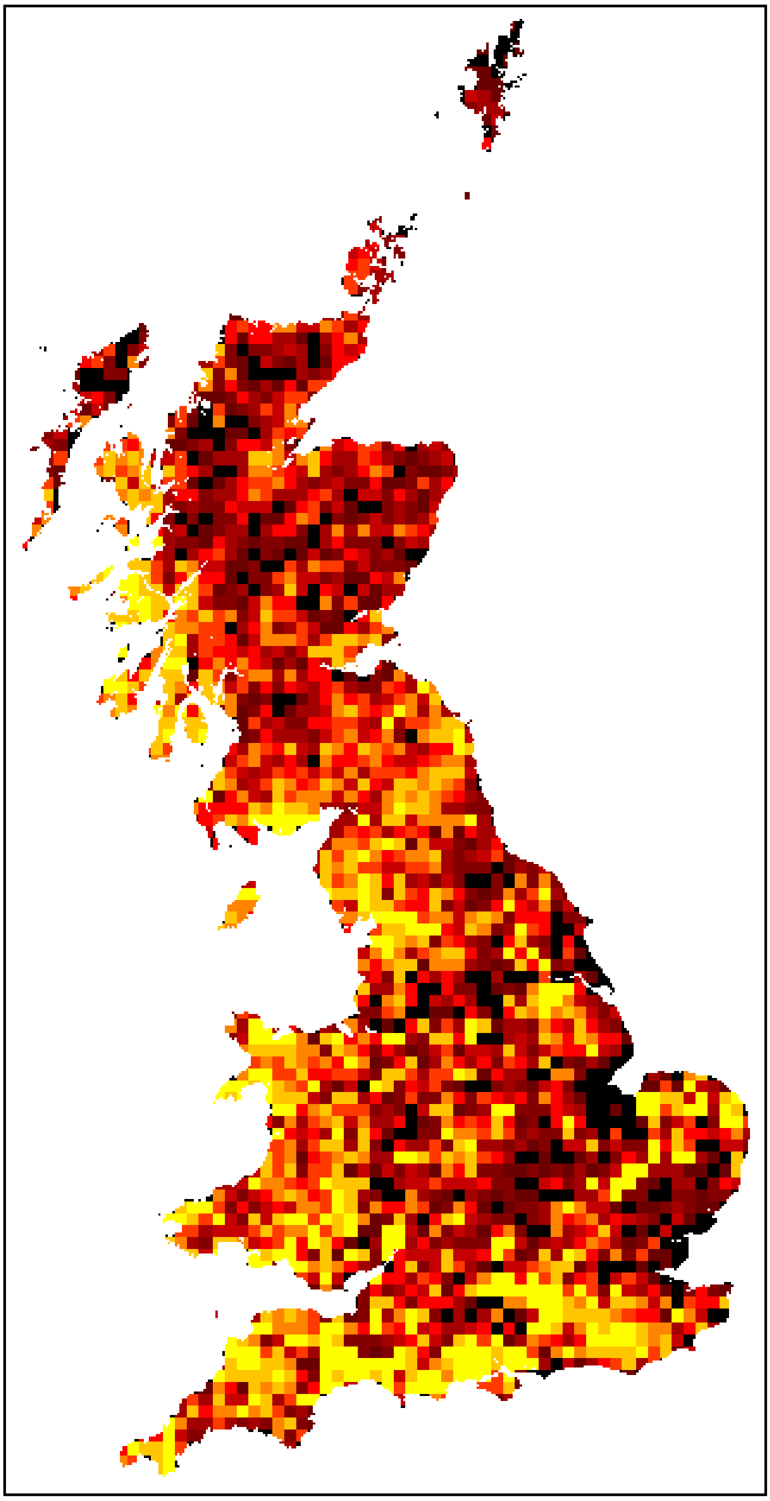
Habitat	Material source	Ref.	Option	Rationale/comments
Coastal and Floodplain Grazing Marsh		1 and 2	B	Initial seeding/other propagules to kick start creation
Eutrophic standing waters			B	Initial seeding/other propagules to kick start creation
Fen			B	Initial seeding/other propagules to kick start creation
Lowland raised bog			B	Initial seeding/other propagules to kick start creation
Purple moor grass and rush pasture		1 and 2	B	Initial seeding/other propagules to kick start creation
Reedbed		1	B	Reed will readily colonise unaided if right conditions persist and reed is already present, however see comment below. As a result option B has been selected.
Saline lagoons			A	Characteristic species will readily colonise on the next tide if right conditions persist
Wet woodland			C	Can be achieved by abandonement but extensive planting/seeding may be needed to achieve cover on reasonable timescales

References

1 Gilbert and Anderson (1998) Habitat Creation and Repair

<u>Comment</u>: this criterion is absolutely dependent upon geographical context. The statement made for reedbeds could equally well be made for the other habitats WHERE the area for ecological creation lies directly adjacent to some area of intact habitat. In addition work by CEH [e.*g*. Mountford, J.O., Roy, D.B., Cooper, J.M., Manchester, S.J., Swetnam, R.D., Warman, E.A. and Treweek, J.R. (2006). Methods for targeting the restoration of grazing marsh and wet grassland communities at a national, regional and local scale. *Journal for Nature Conservation* **14:** 46-66] used co-occurrence maps to assess local species pools for particular habitats/communities and hence the chance that a given community might develop naturally without seeding assuming that the edaphic and hydrological factors were suitable and the right management in place. Note therefore Option B may be a more likely scenario for reedbed creation.

Co-occurrence Map of NVC Community M24 *Molinia caerulea-Cirsium dissectum* Fen-Meadow



Note: Lighter colours indicate higher co-occurrence of species.

Management Requirements

Habitat	Management	Ref.	Option	Rationale/comments
Coastal and Floodplain Grazing Marsh	Annual cut/grazing necessary	1	C	
Eutrophic standing waters	Infrequent or none	4	A	Unlikely to need vegetation management more frequent than every 5 years
Fen	Bi-annual management	2	B	Similar to reedbed, as considering tall herb fen.
Lowland raised bog	Periodic sapling removal but little other management necessary of established habitat	4	A	
Purple moor grass and rush pasture	Grazing or cutting necessary to maintain struct	4	C	Annual management necessary to prevent developing into rank habitat.
Reedbed	2-4 year rotation.	1 and 2	B	Frequency depends upon area and/or resources.
Saline lagoons	Bed-lowering/sluice replacement only every few decades	3	A	
Wet woodland	Coppicing/thinning every 5 years, otherwise nc	1	A	

References

1 Ecoscope Applied Ecologists (2000) Wildlife Management and Habitat Creation on Landfill Sites
2 Sutherland and Hill (2005) Managing Habitats for Conservation
3 Bamber et al (2001) Saline Lagoons: A Guide to Their Management and Creation
4 Professional judgement