Assessing the contribution of agri-environment schemes to climate change adaptation

Natural England

March 2018

Final report

Notice

This document and its contents have been prepared and are intended solely for Natural England's information and use in relation to understanding the contribution of agri-environment schemes to climate change adaptation.

Atkins Ltd. assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 216 pages including the cover.

Document history

Job number: 5138754			**Document ref: DG_5138754_001**			
Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	Draft report to client	PM	FS	GD	GD	18/11/16
Rev 2.0	Final report	PM	FS	MB	MB	22/08/17
Rev 3.0	Report for publication	NvD	NvD	NvD	MB	06/03/18

Client signoff

Client	Natural England
Project	Assessing the contribution of agri-environment schemes to climate change adaptation
Job no.	5138754
Document reference	DG_5138754_005

Table of contents

Tables

Figures

Authors

Paul Munday (first author) – Atkins
Geoff Darch – Atkins
Simon Duffield – Natural England
Trevor Mansfield – Natural England
Nicholas Macgregor – Natural England
Sarah Taylor – Natural England
Mike Morecroft – Natural England

Abbreviations

Acronym	Meaning
ALC	Agricultural Land Classification
ASA	Agreement Scale Assessments
BAP	Biodiversity Action Plan
BETHA	Baseline Environmental (Higher Tier) Assessment
Bio2020	Biodiversity 2020
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CCC	The Committee on Climate Change
CCRA	Climate Change Risk Assessment
CMEF	Common Monitoring and Evaluation Framework
CS	Countryside Stewardship
CSM	Common Standards Monitoring
CSS	Countryside Stewardship Scheme
EA	Environment Agency
EbA	Ecosystem-based Adaptation
EbM	Ecosystem-based Mitigation
EC	European Commission
EHLS	Organic Higher Level Stewardship
ELS	Entry Level Stewardship
ESA	Environmental Stewardship Agreement
EU	European Union
EWGS	English Woodland Grant Scheme
FEP	Farm Environment Plan
FCT	Favourable Condition Target
FWPS	Farm Woodland Premium Scheme
FWS	Farm Woodland Scheme
GHG	Greenhouse gases
GIS	Geographic Information System
HLS	Higher Level Stewardship
ISA	Integrated Site Assessment
JNCC	Joint Nature Conservation Committee
MAFF	Ministry for Agriculture, Fisheries and Food
NAP	National Adaptation Programme
NBCCVM	National Biodiversity Climate Change Vulnerability Model
NCA	National Character Area
NVC	National Vegetation Classification
NVZ	Nitrate Vulnerable Zones
PIF	Permanent Ineligible Features
OELS	Organic Entry Level Stewardship
RAG	Red-Amber-Green
RDP	Rural Development Programme
RDPE	Rural Development Programme for England
RLR	Rural Land Register
RSPB	Royal Society for the Protection of Birds
SSSI	Site of Special Scientific Interest
TA	Thematic Assessments
UAA	Utilisable Agricultural Area
UKCP	UK Climate Projections
WAG	Woodland Assessment Grant
WCG	Woodland Creation Grant
WFD	Water Framework Directive
WGS	Woodland Grant Scheme
WIG	Woodland Improvement Grant
WMG	Woodland Management Grant
WPG	Woodland Planning Grant
WQPA	Water Quality Priority Areas
WRG	Woodland Regeneration Grant

Executive summary

Introduction

This report presents the development of a monitoring protocol to improve our understanding, and enable assessment, of how agri-environment schemes may (or may not) contribute to climate change adaptation. The project is focussed upon adaptation of the natural environment.

The project had the following objectives:

- Define a **monitoring framework** for future agri-environment monitoring that may be used in Rural Development Plan (RDP) reporting; and
- Undertake a detailed spatial analysis to **develop a national baseline** from which future change is able to be compared.

The second objective used the existing pattern of uptake of Environmental Stewardship (ES), including English Woodland Grant Schemes (EWGS), to develop the baseline. Going forward, under Countryside Stewardship, the proposed framework and baseline assessment will enable uptake under the new scheme to be compared and monitored.

Rationale

Climate change adaptation and mitigation have long been overarching objectives of agri-environment schemes. Despite this, recent documentation largely omits mention of climate change, the assumption appearing to be that climate change adaptation and mitigation will be achieved through the delivery of the schemes' other objectives, primarily those on biodiversity and water.

Developing the monitoring framework

Background

A number of different monitoring protocols already exist for agri-environment schemes. Indeed, over time the evolution of England's monitoring programmes of agri-environment schemes have been driven by the need to evaluate the wider contribution made by agri-environment schemes. This includes targets for biodiversity, water quality and landscapes, as well as understanding the broader contribution made to sustainable development. This has led to the incorporation of various monitoring schemes into ES (e.g. condition assessments of SSSIs and Agreement Scale Assessments) and has facilitated the effective reporting of the contribution of ES to other domestic policy objectives (e.g. Biodiversity 2020 and 'Aichi' targets). However, despite the comprehensive monitoring programme and metrics used to spatially target schemes, there is no such framework for monitoring and/or assessment of the contribution that agri-environment schemes make towards climate change adaptation.

Methodology

Framed by the Government's National Adaptation Programme (NAP) objectives[1] and in conjunction with our understanding of the broader environmental benefits provided by agri-environment schemes, we developed a set of **monitoring objectives** for agri-environment schemes. Each objective primarily aimed to promote adaptation for the natural environment, Ecosystem-based Adaptation (EbA) (using the natural environment to support adaptation in other sectors) or ecosystem restoration and Ecosystem-based Mitigation (EbM).

These broad outcomes were then regrouped and developed into a more specific set of **adaptation indicators** for monitoring and a number of monitoring questions also identified. The set, developed for monitoring at the national-scale, is presented in Table 1 (overleaf).

[1] Namely: building ecological resilience; preparing for and accommodating change; valuing wider adaptation benefits and improving the evidence base

Table 1. List of adaptation indicators

Adaptation principles for conservation (based on NAP objectives)	Adaptation indicators	Monitoring question
A. Protecting the most important and vulnerable sites	A1. Maintenance and restoration options will be coincident with priority habitats	What is the proportion of priority habitat covered by maintenance and restoration options?
	A3. Agri-environment schemes will support SSSIs	What is the proportion and total area of SSSIs covered by maintenance and restoration options?
	A4. Restoration and maintenance options will support highly sensitive habitats	Of habitats with High, Medium or Low (and 1-5) sensitivities, what is the proportion under appropriate restoration and maintenance options?
	A5. Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)	What is the area of creation option uptake by sensitivity class?
B. Reducing fragmentation and enhancing ecological networks	B1. Creation options will reduce fragmentation	What is the proportion and total area of appropriate creation options in each fragmentation buffer?
	B5. Matrix options to restore or create features should be focused in areas of high fragmentation	What is the proportion and total area of appropriate creation and restoration matrix options in the high fragmentation buffer?
	B7. Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species	What is the proportion of appropriate woodland creation options that fall within 1km of woodland habitat networks?
C. Protecting refugia	C1. Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia	What is the area of appropriate creation, maintenance or restoration options in areas of high and low refugia?
D. Planning for potential changes in species' ranges and assemblages	D1. Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions	What is the total area of appropriate options in relation to the priority areas of future ranges of taxa?
E. Restoring ecosystems	E1. Creation and restoration options will be focused within areas supporting the Outcome 1D objective	What is the proportion and total area of Outcome 1D potential areas covered by creation and restoration options?
F. Making species populations more resilient	F1. Creation options around existing semi-natural areas will create larger conservation sites	What is the proportion and total area of creation options abutting existing habitat and within 0.5km, <1km and >1km of existing priority habitats?
G. Improving water quality and reducing flood risk	G1. Matrix options for soil protection will be focused in Water Quality Priority Areas	What is the proportion and total area of Water Quality Priority Areas covered by appropriate matrix options?
H. Storing and sequestering carbon	H1. Agri-environment schemes contribute to the storage and sequestration of carbon	What is the proportion (and area) of blanket peat and peat soils with appropriate options on?
I. Targeting and applying interventions in a cost-effective and adaptive way	I1. Adaptation in the natural environment will be consistent with agricultural adaptation.	What is the area of core habitat creation options within each Agricultural Land Classification (ALC) grade?

At the national-scale, these adaptation indicators were evaluated using a Geographic Information System (GIS)-based approach that made use of spatial patterns of option uptake compared with various underlying spatial datasets (the results of which are described in the sub-section that follows).

At the local-scale, recommendations were made for monitoring that utilises a ground-truthing of the national-scale baseline assessment and that is supported by a programme of field surveys, consultations with land owners and reviews of agreement operation, and option and prescription[2] choice. In addition, a number of success criteria and measures of change were developed to aid reporting and future monitoring.

[2] Guidelines that land owners must adhere to in order to ensure that they meet the management requirements for options applied on their land. For each option there are usually multiple prescriptions.

We have then explored whether the current agri-environment scheme (Countryside Stewardship) is likely to deliver positive change to the indicators based on its current design and operation. The resulting monitoring framework provides a robust mechanism by which to evaluate the ability of, and progress of, current (and new) schemes to deliver climate change adaptation, and also EbA and EbM.

Developing the (national-scale) baseline assessment

We reviewed a number of spatial datasets, including data on habitat vulnerability, fragmentation and sensitivity, flood risk, soils and water quality, to develop the baseline assessment.

To help synthesise the vast number of options available to land managers under agri-environment schemes, we developed an Excel tool that can be used to filter ES options depending on a range of variables, including the type of option, whether the option supported core habitat creation or permeability through the landscape (matrix) and a broad categorisation (e.g. maintenance, restoration or creation). The tool forms a key output of this project. We then presented a detailed evaluation of each of the adaptation indicators, including questions that may be used to test each indicator at the national-scale and the data available to facilitate monitoring. In each case, we undertook a Red-Amber-Green (RAG) assessment to describe our confidence in the data that were available to test each indicator. Based upon this evaluation, a subset of the adaptation indicators was used in the baseline assessment.

Results from the baseline assessment

Table 2 (overleaf) lists the adaptation indicators, associated monitoring questions and provides a summary of the results. Note, results for all indicators (i.e. those at both the national- and local-scales) are provided for clarity.

Table 2. Summary of results from the baseline assessment

Principle	Adaptation indicators	Monitoring question	Summary of result
A. Protecting the most important and vulnerable sites	A1. Maintenance and restoration options will be coincident with priority habitats	What is the proportion of priority habitat covered by maintenance and restoration options?	On average, across all priority habitats within England, around half (~49%) of priority habitats eligible for agri-environment schemes are covered by the selected maintenance and restoration options. Across England, ~79% of priority habitats are located within the eligible area.
	A2. The condition of priority habitat under agri-environment management will be higher than that of priority habitat not under management	Assessed at the local-scale, not part of the national-scale assessment. Whilst data exists on habitat condition these are locally produced and the results of which reported nationally. Reporting condition outside of priority habitats is also problematic as this data is seldom available outside of comprehensive monitoring frameworks.	
	A3. Agri-environment schemes will support SSSIs	What is the proportion and total area of SSSIs covered by maintenance and restoration options?	Point agri-environment data is not of a sufficient resolution to draw conclusions regarding the proportion of SSSIs covered by selected maintenance and restoration options. Our analysis sums the total area of these options that are located within the SSSIs and calculates a proportional coverage. This is misleading in this particular case as the land area in agreement (represented by a single point) may or may not wholly cover the SSSIs and therefore only part of the SSSI may actually be covered by a selected maintenance and/or restoration option. As a result, the outputs presented here should be treated with caution. Fully georeferenced data (output from GENESIS) is required. This indicator will be monitored at the farm-scale.
	A4. Restoration and maintenance options will support highly sensitive habitats	Of habitats with High, Medium or Low (and 1-5) sensitivities, what is the proportion under appropriate restoration and maintenance options?	The majority of restoration and maintenance option uptake is on habitats with a medium sensitivity (~73%) using the sensitivity classification adopted in the NBCCVA study; there is significantly less uptake on habitats with High (~9%) and Low sensitivities (~5%). Using our own classification, a similar trend is evidence with the majority of uptake on habitats with sensitivities in bands 2 (~33%) and 3 (~44%) and less in band 1 (~6%), band 4 (~9%) and band 5 (~8%).
	A5. Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)	What is the area of creation option uptake by sensitivity class?	Data on habitat creation at the national level is restricted to broad categories, for example grassland creation. This resolution is too coarse to draw sensible conclusions regarding the ability of agri-environment schemes to compensate for projected losses of different habitats. Farm-scale monitoring will provide the necessary detail to monitor this indicator.
	A6. Agri-environmental management will create shade for rivers where this is a priority for the freshwater habitat	Assessed at the local-scale, not part of the national-scale assessment.	
B. Reducing fragmentation and enhancing ecological networks	B1. Creation options will reduce fragmentation	What is the proportion and total area of appropriate creation options in each fragmentation buffer?	There is little evidence to suggest that areas of high habitat fragmentation are the focus for habitat creation. In addition, there is very little difference in the uptake of habitat creation options between areas that are highly fragmented and those that are less highly fragmented. For all fragmentation indicators relating to priority habitats (B1 and B5), there is little evidence of geographical bias.
	B2. Restoration options will support the reduction of fragmentation	What is the proportion and total area of appropriate restoration options in each fragmentation area?	There is little evidence to suggest that highly fragmented areas are the focus for habitat restoration. In addition, there is very little difference in the uptake of restoration options between areas that are highly fragmented and those that are less highly fragmented. However, there is greater uptake of restoration options than that of creation (indicator B5). For all fragmentation outcomes of priority habitats (B2 and B5), there is little evidence of geographical bias.

Principle	Adaptation indicators	Monitoring question	Summary of result
	B3. Woodland creation options will help to reduce woodland fragmentation	Assessed at the local-scale, not part of the national-scale assessment.	
	B4. Woodland restoration and maintenance options will support the reduction of woodland fragmentation	Assessed at the local-scale, not part of the national-scale assessment.	
	B5. Matrix options to restore or create features should be focused in areas of high fragmentation	What is the proportion and total area of appropriate creation and restoration matrix options in the high fragmentation buffer?	There is little evidence to suggest that highly fragmented areas are the focus of ES. For all fragmentation outcomes of priority habitats (B2 and B5), there is little evidence of geographical bias.
	B6. Creation options will enhance ecological networks	Assessed at the local-scale, not part of the national-scale assessment.	
	B7. Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species	What is the proportion of appropriate woodland creation options that fall within 1km of woodland habitat networks?	It is difficult to determine the pattern of uptake of woodland creation within (or close to) woodland habitat networks due to the relative abundance of woodland habitat and the associated search radius of 1km. It is recommended that a better measure would be to identify the best sites for woodland creation and the proximity (abutting, <0.5km, <1km and >1km) of woodland creation options from these sites.
C. Protecting refugia	C1. Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia	What is the area of appropriate creation, maintenance or restoration options in areas of high and low refugia?	Habitat creation appears to favour (i.e. there is a greater concentration) areas with high refugia potential. There is also greater uptake of maintenance and restoration of habitats within areas of high refugia potential than within areas with low refugia potential. Notably, there is no specific targeting of ES schemes to areas of high refugia potential so the relationship is coincidental.
D. Planning for potential changes in species' ranges and assemb-lages	D1. Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions	What is the total area of appropriate options in relation to the priority areas of future ranges of taxa?	The appropriate responses to climate change driven changes in the location of priority areas for species require more consideration before changes to agri-environment scheme targeting and prioritisation are made.
	D2. Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations	What is the total area of all matrix options in areas of projected high or low species turnover?	There is no clear relationship between the uptake of creation and restoration options that support the matrix and areas of high or low species turnover. There is significantly greater uptake of maintenance and restoration options within areas of high species turnover (~3,993 ha) than those with low species turnover (~246 ha).
E. Restoring ecosystems	E1. Creation and restoration options will be focused within areas supporting the Outcome 1D objective	What is the proportion and total area of Outcome 1D potential areas covered by creation and restoration options?	The analysis is not possible without polygonised agri-environment scheme data due to the limited coverage of the habitat potential area datasets and the accuracy of the ES scheme data. Analysis of habitat potential should there be undertaken at the farm-scale.
F. Making species populations more resilient	F1. Creation options around existing semi-natural areas will create larger conservation sites	What is the proportion and total area of creation options abutting existing habitat and within 0.5km, <1km and >1km of existing priority habitats?	The majority of habitat creation occurs within 1km of existing priority habitat, but not abutting it. Woodland habitats are an exception, where the vast majority of woodland creation occurs abutting existing priority habitat. However, this should be treated with caution given the relative abundance of woodland patches in England when compared with other habitat types. Where woodland habitat is created, Woodland Creation Grants account for ~81.5% of all woodland habitat creation abutting existing priority habitat.
	F2. Creation options increase the topographic heterogeneity of habitats	Assessed at the local-scale, not part of the national-scale assessment.	

Principle	Adaptation indicators	Monitoring question	Summary of result
G. Improving water quality and reducing flood risk	G1. Matrix options for soil protection will be focused in Water Quality Priority Areas	What is the proportion and total area of Water Quality Priority Areas covered by appropriate matrix options?	Across all 10km x 10km grids that contain a high priority WQPA, uptake of options that support soil protection within these areas is ~4.8%. The Pennines and West Midlands generally see the most comprehensive coverage.
	G2. There will be a greater concentration of relevant agri-environment schemes options within flood prone areas to reduce flood risk	Assessed at the local-scale, not part of the national-scale assessment.	
	G3. Agri-environment schemes will support the objectives of the Woodlands for Water programme	Assessed at the local-scale, not part of the national-scale assessment.	
H. Storing and sequest-ering carbon	H1. Agri-environment schemes contribute to the storage and sequestration of carbon	What is the proportion (and area) of blanket peat and peat soils with appropriate options on?	Only blanket peat and peat soils were considered. The majority of blanket peat soils (~73%) are covered by options whilst the majority of peat soils (~91%) are not covered by any options. There is therefore greater uptake on blanket rather than peat soils. Over both of these soil types and across both creation, maintenance and restoration options, ~85% of blanket peat soils are covered by options whilst uptake on peat soils is substantially lower (~18%). Therefore, selected agri-environment scheme options are not implemented on most peat soils.
I. Targeting and applying intervent-ions in a cost-effective and adaptive way	I1. Adaptation in the natural environment will be consistent with agricultural adaptation.	What is the area of core habitat creation options within each Agricultural Land Classification (ALC) grade?	Excluding Woodland Creation Grants, uptake of options that support habitat creation is generally greater within the highest quality (grades 1-3) agricultural land grades (54%) than the lower grades (grades 4 and 5) (46%). When Woodland Creation Grants are included, uptake is similar although there is slightly more uptake in the higher (60%) than the lower (40%) grades.
	I2. Options will be implemented in a flexible way to facilitate adaptive management	Not assessed through a national analysis of uptake patterns, but through a qualitative assessment of scheme design and operation.	
	I3. Agri-environment options will accommodate change where appropriate	Assessed at the local-scale, not part of the national-scale assessment.	

Conclusions

This project represents, to our knowledge, the first attempt in Europe to develop a robust methodology and baseline assessment of the ability of agri-environment schemes to deliver climate change adaptation for the natural environment.

Below are our summarised findings, separated by adaptation principles.

A. Protecting the most important and vulnerable sites

The results of the national baseline assessment demonstrate that current agri-environment schemes are making some contribution to delivering adaptation and EbA. However, the extent to which they are doing so varies considerably. The greatest contribution is where the climate change outcome overlaps with other key objectives of the scheme, such as delivery of commitments to biodiversity (indicator A1). This is to be expected as the targeting of semi-natural habitats is a key component of the scheme through meeting Biodiversity 2020 objectives.

For SSSIs (indicator A3) the picture is less clear. Despite targeting of agri-environment schemes to protect these areas, the lack of availability of high resolution agri-environment scheme data (i.e. field-scale, polygonised) means that assessment at is unclear at the national-scale. This is due to the use of agri-environment scheme point data and the coincidence of these points with SSSIs. Our analysis sums the total area of these options that are located within the SSSIs and calculates a proportional coverage. This is misleading in this particular case as the land area in agreement (represented by a point) may or may not wholly cover the SSSIs and therefore only part of the SSSI may be covered by an option. As a result, the outputs presented here should be treated with caution. Therefore, high-resolution data is fundamental in understanding spatial uptake of agri-environment management at the national-scale, whilst farm-scale monitoring is a useful/additional substitute at present.

Targeting the most sensitive habitats to climate change can help to build resilience (see indicators A4 and A5). It is often the case that many of the highly sensitive habitats (e.g. lowland raised bog and coastal saltmarsh) do not have large land areas in the Utilisable Agricultural Area (UAA) and therefore are not easily targeted under ES, or they do not have appropriate options to increase resilience (e.g. saline lagoons and maritime cliffs and slopes). Conversely, coastal and floodplain grazing marsh and upland hay meadows are both highly sensitive and have good option coverage although, particularly at the coast, multiple pressures may mean that putting agri-environment management in place may be increasingly difficult with climate change (i.e. due to access and/or coastal change). When looking at habitat creation in more detail (indicator A5) the resolution of the agri-environment data is not sufficient to draw sensible conclusions regarding the ability of agri-environment schemes to compensate for projected losses of different habitats. It is therefore recommended that farm-scale monitoring is used to identify these changes as the target habitats will be recorded at the agreement level.

B. Reducing fragmentation and enhancing ecological networks

Traditionally, conservation effort has focused on building resilience through actions to reduce non-climatic adverse drivers on existing biodiversity, such as inappropriate management and diffuse pollution. Since the Lawton report (Lawton *et al.*, 2010), additional focus has been on strengthening ecological networks through addressing fragmentation. The current pattern of uptake (see indicators B1, B2 and B5) demonstrates that agri-environment management is making a limited contribution to these objectives. There is little evidence to suggest that highly fragmented areas are the focus for habitat creation. In addition, there is very little difference in the uptake of selected core creation options between areas that are highly clustered and those that are less highly clustered. For all fragmentation indicators of priority habitats (B1, B2 and B5), there is little evidence of geographical targeting. There is evidence of slightly more restoration (B2) in highly fragmented areas. For woodland creation (indicator B7), the pattern of uptake is inconclusive and further study is required.

C. Protecting refugia

Although the evidence for the existence of landscape-scale climate change refugia is new and agri-environment scheme prioritisation is not currently a targeting mechanism for them, habitat creation under agri-environment schemes appears to favour areas (i.e. there is a greater concentration of options) with high refugia potential. There is also greater uptake of maintenance and restoration of habitats within areas of high refugia potential than within areas with low refugia potential. Good quality data at the national-scale is available whilst, at the farm-scale, there is evidence for the importance of topographic heterogeneity and reliable water supply in supporting micro-refugia, however, useable guidance on their identification is not presently available. Uncertainty also exists around what the most appropriate adaptation responses should be and how these might be delivered through agri-environment schemes. Therefore, this is an evolving area of research and one in which Natural England are already active. It is therefore recommended that Natural England review the evidence base as it develops against the proposed monitoring framework.

D. Planning for potential changes in ranges and assemblages of species

Conservation management can only be applied over a relatively small percentage of the land area and therefore needs to be carefully managed on the most important places. Current work with the University of York and Natural England is investigating the highest priority areas for protecting a suite of species. Our results (indicator D1) suggests that there is no clear relationship, or targeting, of agri-environment schemes to these high priority areas. However, the current evidence base requires further work to support the indicator and the appropriate actions to respond to it.

In terms of the targeting of agri-environment schemes to areas of projected high/low species turnover (indicator D2), there is no clear relationship of targeting to these areas. The reasons for this are unclear, however a possible cause may be that areas with greater concentrations of semi-natural habitat, and therefore with higher species diversity, are more likely to change; these areas are not reflected in the underlying spatial datasets at present (i.e. areas are depicted that simply provide areas of semi-natural habitats but not the species richness or diversity of these habitats). Further study is therefore required to better understand the relationship between agri-environment management and changes within areas of projected high species turnover.

E. Restoring ecosystems

The UK's commitment to restoring degraded ecosystems via targets delivered as part of the Biodiversity 2020 (Bio2020) objectives are clear and a range of national-scale targeting layers have been produced and used in this project against uptake of agri-environment schemes. However, the limited spatial granularity of the agri-environment scheme data, combined with the relatively high resolution data used to target agri-environment schemes, means that there is limited visible uptake evident within these areas (see indicator E1); the current method of assessment at the national-scale is therefore not appropriate. At the farm-scale, the national-scale data may be ground-truthed but current assessment is likely to be insufficient for national reporting of Bio2020 targets.

F. Making species populations more resilient

To improve resilience to climate change, ecological networks should be based on a core set of high quality sites of sufficient size. Making existing sites bigger is a recognised method for supporting adaptation goals. Assessment of habitat creation around existing semi-natural areas (indicator F1) suggests that the majority of habitat creation occurs within 1km of existing priority habitat; this is good for improving connectivity of ecological networks and for building resilience to climate change. For wetland sites, most habitat creation occurs over 1km from existing wetlands and the reasons for this are unclear. In this regard, a clear focus on prioritising habitat creation close to existing wetland sites is needed.

G. Improving water quality and reducing flood risk

Despite strong evidence on the benefits of specific land management activity on improving water quality there is limited evidence of uptake of these options (that support improvements in water quality through protecting soil resources) within high priority areas (indicator G1). Fully georeferenced agri-environment data is required to better assess (and monitor) the contribution of this indicator to climate change adaptation. Clear prioritisation is needed to enable agri-environment schemes to contribute to this indicator.

H. Storing and sequestering carbon

Only peat and blanket peat soils were considered in the national-scale assessment (indicator H1). Uptake of options that support these soils was high on blanket peat soils (~73% covered by options) and very low on peat soils (~9%). Although sequestration of carbon is unlikely to be a significant driver of option choice, the benefit to climate change mitigation and adaptation is well established. For example, restored and/or maintained peat soils are likely to retain water, thereby improving flood risk and water quality.

I. Targeting and applying interventions in a cost-effective and adaptive way

The spatial analysis of option uptake was only able to assess one of the indicators that focussed on targeting and applying interventions in a cost-effective and adaptive way. For the other indicators, preliminary conclusions can be drawn from the discussions held on scheme design and operation, the workshops and the interviews undertaken with key Natural England staff and staff from other organisations. An overarching concern of staff is how the recent changes to the inspection and penalty regime is impacting on the ability of agri-environment schemes to support the ways of working required to promote adaptation. The requirement for auditability of options and prescriptions and the potential threat of penalties if indicators of success are not met are likely to increase the conservative nature of agreement holders and advisors when setting up agreements. This will make the accommodation of change, and the requirement for increased flexibility in response to climate change harder to achieve.

Monitoring at the national- and farm-scales

This project has highlighted the difficulty (and complexity) of translating high-level adaptation principles into indicators that can be monitored at different spatial scales. At the national-scale, the location-specific nature of the threats (and opportunities) that climate change poses, and the range of appropriate adaptation responses, makes identifying measurable and standardised indicators a challenge. This is often further compounded by a lack of data richness (i.e. lack of detail) and sometimes poor granularity of data (i.e. poor spatial resolution and/or geometry, such as ES point centroid data).

The national element of monitoring requires both an assessment of the scheme structure and design, and the data on the spatial pattern of uptake. These will need to be undertaken at different times in the evolution of the scheme. The assessment of scheme design should be undertaken early in the scheme development so that findings can be incorporated at the earliest opportunity. It is therefore imperative that climate change input is sought early in the development of the replacement for the current RDPE.

Monitoring at the farm-scale provides the resolution necessary to determine local issues and evaluate the contribution that schemes are making to appropriate delivery. The farm-scale also provides the opportunity to monitor not just where the schemes are operating, but also how the scheme is operating on the ground, thereby enabling an assessment of the ability of schemes to deliver the necessary flexibility and promotion of adaptive management on-farm. However, ensuring sufficient coverage to determine clear patterns will be a challenge. This makes monitoring, at a range of spatial scales, a prerequisite for assessing the contribution that agri-environment schemes can make to climate change adaptation. Further, assessment of scheme uptake should be undertaken periodically and/or towards the end of the scheme life.

A wide range of spatial (and non-spatial) data are required to undertake such an assessment as this. With regard to the agri-environment scheme data, the availability of data at relatively fine resolution (either field centroid or fully georeferenced data, the latter being preferred) is fundamental, especially to monitor those metrics that require greater granularity, such as fragmentation (indicators B1, B2, B3, B4, B5, B6 and B7) or making existing sites larger (indicator F1). It is therefore imperative that data captured and managed from Countryside Stewardship are sufficiently detailed (and of a high quality) to facilitate future scheme monitoring. Fully georeferenced (and quality checked) agri-environment scheme data should therefore be made available.

The project was also able to make use of many existing and freely available spatial datasets that describe the underlying environmental landscape. However, in some cases, the data either did not exist, or were not publicly available e.g. some information on riverine shading and flooding. For future monitoring, it is therefore important that existing datasets are made available and additional data on understanding the benefits of agri-environment schemes to reducing flood risk are created.

Wider applications and implications:

There are wider applications (and implications) of the work undertaken, including:

- The work facilitates the reporting on environmental impacts of agri-environment schemes as part of RDPs against the backdrop of an increasing need to report outcomes from monitoring schemes;
- For the first time in Europe, to our knowledge, we have produced method for assessing the state of adaptation on the ground and of ground-truthing a national-scale baseline assessment (which is essential if reporting is to be meaningful);
- The development of the monitoring framework and national-scale baseline assessment can directly influence agri-environment delivery to increase the contribution of agri-environment schemes to climate change adaptation. The current baseline assessment suggests that current delivery is not reaching its full potential and more could be done to prioritise and improve the multiple benefits to the environment provided by agri-environment schemes;
- In undertaking this project, wider links to other Natural England projects are evident, including work on understanding species refugia, fragmentation and Bio2020 targets; and
- Finally, in addition to these direct uses there is potential for wider application of the methodology and monitoring framework developed here to areas outside of the UK i.e. other EU countries that employ agri-environment schemes.

Recommendations

Based upon our findings, the following additional recommendations were made for the operation of the proposed monitoring methodology:

- The methodology developed for the **on-farm assessment should be integrated with future agri-environment scheme monitoring programmes**. This will require embedding into monitoring programmes that monitor at both the start and end of agreements;
- The national assessment presented here should be **repeated between every 2-5 years** and as indicated (Section 5.3) to coincide with scheme start/end dates. Attention should be made to using the farm-scale assessments to inform the national assessment and to build in lessons learnt and flexibility into the monitoring framework;
- **National monitoring** of spatial uptake patterns should be undertaken at the end of the scheme's life and/or on single schemes;
- **Fully georeferenced data should be collated, quality checked and made available**. Under ES such data is collected using GENESIS. This data needs to be complete and quality controlled to improve the resolution of the national monitoring. This is especially important for those metrics that require detailed spatial resolution. Future schemes including CS should have a data gathering system that provides this data; the spatial data supplied via Genrep enabled the national analysis of most indicators to be undertaken. The current data represents the minimum that is required for reporting. Fully geo-referenced data (as available from Webmap) would significantly improve the resolution of the some of the national analysis that requires precise spatial information; and
- **Underpinning spatial datasets should be made available**. Several datasets held by Defra family organisations were not available for this project.

1. Introduction

1.1. Adaptation context

It is widely accepted that climate change will have impacts on the natural environment in both the short- and long-term. In the UK, land temperatures have risen by as much as 1˚C since the 1970s and the UK has experienced eight of the ten warmest years on record over the same period (Met Office, 2009). Coastal sea surface temperatures have risen by approximately 0.7˚C whilst sea levels are estimated to have risen by approximately 10 cm since 1990. The UK Climate Projections (UKCP09) contain information on past and future projections of climate change; these trends are projected to continue dependent upon the volume (and resulting concentrations) of greenhouse gases (GHG) that are released into the atmosphere, as well as other factors including residence time in the atmosphere and the nature of absorption by land and oceans (IPCC, 2013).

Our changing climate already has, and is expected to have, impacts upon the natural environment in a variety of ways. For example, many species are now found further north, including some which have colonised large parts of the UK from continental Europe (Morecroft and Speakman, 2015). There have also been changes in the composition of some plant, microbial and animal communities, consistent with different responses by species to rising temperatures (Morecroft and Speakman, 2015). Direct impacts on species include changes in abundance and species distribution and changes to the timing of seasonal events. Individual species may adapt through changes to the way they use different habitats. As a consequence, various changes have already been, and continue to be, recorded and there will be further changes in the future (Morecroft and Speakman, 2015; Natural England, 2010). Over time, warmer temperatures and/or changes to seasonality will have direct economic impacts upon the types of crops that can be grown and agricultural yields. In addition, less obvious indirect impacts will become just as significant as a result of climate-induced changes in land use having knock-on effects on biodiversity. For example, growing new crops, increases in summer water availability and geographical shifts in arable and livestock production could well occur (IACCF, 2010; Natural England and RSPB, 2014). A comprehensive overview of the key climate change risks to the UK, including the natural environment, is provided by the UK Climate Change Risk Assessment (see Defra, 2012; Climate Change Committee, 2016).

Whilst emphasis has largely been placed on the direct impacts of climate change, the way society responds (adapts) to climate change, the indirect impacts, will also impact on the natural environment. Adaptation to climate change is necessary in order to manage negative impacts but also to ensure that we are best placed as a society to benefit from any opportunities that may arise (Defra, 2010). For example, in some areas of the UK climate change could also offer wider opportunities for tourism and warmer temperatures could lead to opportunities to grow new crops and/or increases in grassland productivity. There is increasing evidence that the natural environment can be managed in ways that will help society adapt to climate change, as well as providing benefits to nature and its conservation; this is often referred to as ecosystem-based adaptation (EbA) and examples include creating wetland habitats in areas that are at high risk of flooding and creating green spaces or planting trees in built-up urban areas to lower local temperatures (Natural England and RSPB, 2014). Within the UK, the National Adaptation Programme (NAP) (see HM Government, 2013) sets out the Government's priorities for adaptation.

Actions to promote adaptation will also need to deal with uncertainty, in terms of future changes in the climate (e.g. different emissions scenarios, model uncertainty), but also in the increased variability of the climate, both within and between seasons and years. The majority of projections suggest the frequency of extreme events (drought, heatwaves) and heavy rainfall events (flooding) will increase, with similar trends already occurring. Flexibility therefore needs to be built in to long-term planning (Jones *et al*., 2014), but also the short term (within year) planning and operation of agricultural businesses.

Elsewhere, the concept of adaptive management (that is, the cyclical process of targeted action, monitoring, review and, if necessary, revision of actions) has become especially important to climate change adaptation, particularly where the nature of impacts and the effectiveness of adaptation measures is unclear (Natural England and RSPB, 2014). Moreover, the timescales over which adaptation actions take effect may be quite short (e.g. grassland management or increasing rain water capture) whilst other measures may take appreciably longer (e.g. creating new habitats, especially woodlands). Given the longevity of many adaptation measures and the evidence of impacts being felt, it is therefore important to start adaptation now.

Arising from our increasing awareness of the benefits of developing systematic and collaborative approaches to adaptation, a number of studies have been produced that propose a set of adaptation principles (see

Defra 2007a; Defra 2008). The Government's NAP sets out four key objectives for adaptation in the natural environment, namely:

- Building ecological resilience to the impacts of climate change;
- Preparing for and accommodating inevitable change;
- Valuing wider adaptation benefits the natural environment can deliver; and
- Improving the evidence base.

Table 1-1 summarises these objectives.

Table 1-1 Summary of NAP objectives for adaptation

Theme	Summary	Supporting evidence
Building ecological resilience to the impacts of climate change	Building resilience focuses on reducing the adverse impacts of climate change and enabling species, habitats and landscape features to persist in the face of climate change. Evidence suggests that reducing non-climate sources of pressure or harm, such as pollution or habitat fragmentation, can help ensure that fauna are better able to cope with stresses from climate change. Preventing the introduction of pests, diseases and invasive species will also enhance the resilience of a site to climate change. Catchment management can help to ensure sustainability of water supplies in times of drought and reduce the risks of flooding in periods of high rainfall. Improving food supply and/or creating on-site areas of climate refugia to protect species from weather extremes, can improve chances of species persistence. An important element of resilience is maintaining sufficiently large and robust populations that can survive the impacts of extreme climatic events (e.g. droughts or heat waves) that may become more frequent with climate change. Resilience can be addressed at different spatial scales which may allow for increased climatic vulnerability in particular places, provided suitable habitats are available elsewhere within a larger, functionally connected, surrounding area. Lawton *et al.,* (2010) identified that 'more, larger, better and joined up' wildlife sites were fundamental to improving ecological resilience to climate change. Another important aspect is accepting, or even promoting, change in one aspect of the environment in order to improve resilience in another.	Lawton *et al.*, 2010 Morecroft *et al.,* 2012 HM Government, 2011
Preparing for and accommodating inevitable change	Whilst we are able to reduce the risk of adverse impacts of climate change through building resilience, some change is inevitable and some may be welcomed (e.g. a species on the edge of its distribution may increase in population as temperatures rise – the Dartford Warbler is a good example). Accommodating change refers to both the physical and biological environment. Managed realignment may work in tandem with natural coastal erosion to reduce the impacts and so maintain geological features and coastal habitats. Similarly, restoring the natural meandering flow of rivers allows water to disperse naturally and, in the right places, can benefit biodiversity and enhance the landscape whilst improving flood resilience. An important component of accommodating change is facilitating the movement of species populations in response to changing climatic conditions; this applies across all spatial scales: nationally, regionally and locally.	Defra, 2008 HM Government, 2011
Valuing wider adaptation benefits the natural environment can deliver	The natural environment, when managed appropriately, can provide opportunities to help society to adapt to climate change, while also benefiting nature. The NAP encourages the use of ecosystem-based approaches to foster adaptation in other sectors wherever possible. Flood management and urban shading are good examples.	Doswald and Osti, 2011 HM Government, 2011
Improving the evidence base	Over recent years the evidence base on climate change and the natural environment has strengthened significantly and it provides a sufficient basis for embedding adaptation thinking into land management decision making. Uncertainties remain however and, whilst these should be acknowledged in adaptation actions, they may also be reduced by research and practical experience. A list of evidence gaps has been published alongside the LWEC Climate Change Report Cards for biodiversity. Better understanding of these areas will improve our capacity to anticipate change and to implement effective interventions. Monitoring changes as they occur, or in anticipation of them occurring, is also important to evaluate the effectiveness of measures.	LWEC, 2013 HM Government, 2011

The objectives outlined above provide a general framework within which we are able to understand the type, and degree to which, adaptation to climate change is required. However, climate change impacts, vulnerability and resilience are likely to affect different parts of the country in different ways. For example, the ability to grow new crops in the South East of England as relative temperatures are expect to rise quicker than those in the north may mean that our adaptation responses will need to vary accordingly. Moreover, changes to seasonality and the movement of species that track changes to climate will impact upon the nature, and type, of adaptation measures that are required. Accordingly, appropriate adaptation to climate change is likely to be required in different places and at different times.

1.2. Project background

1.2.1. Policy context

The EU has long been committed to international efforts to tackle climate change through robust policy-making. The climate imperative is given emphasis through the setting of the ambition that at least 20% of the EU budget should be used to support climate change objectives.

In keeping with the approach adopted for delivering other environmental priorities, climate change objectives are embedded in EU policy by being integrated into existing EU policy frameworks, notably the Common Agricultural Policy (CAP), Regional Policy and their associated funding streams. Thus, climate change objectives are supported within a framework focussed on Jobs and Growth, Rural Development and Agricultural support.

The aims of the CAP have evolved since its original introduction in 1962 as a catalyst for increasing post-war food production; it is now one of the primary mechanisms for delivering environmental objectives through paying farmers and/or land managers for the provision of environment services (via agri-environment schemes) that protect and enhance the environment.

Pillar 2 of the CAP provides the European statutory basis for agri-environment schemes, as part of Member States' Rural Development Programmes (RDPs). Climate Change adaptation and mitigation are now overarching objectives for the CAP, meaning that these objectives must be reflected in Member States' RDPs (see European Commission, 2010).

1.2.2. What are agri-environment schemes and the English Woodland Grant Scheme?

Agri-environment schemes are voluntary incentive schemes that provide payment to land managers in return for land management that protects the environment and goes beyond the minimum statutory requirements. Agri-environment schemes are part-funded by the CAP with funding coordinated through the Member States' Rural Development Programmes. In England, the Rural Development Programme for England (RDPE) aims to improve the natural environment; increase the productivity and efficiency of farming and forestry businesses and promote strong rural economic growth (Defra, 2014).

Specific voluntary incentive schemes are available for woodlands. This was previously called the English Woodland Grant Scheme (EWGS) and since 2014 is included in a single environmental land management scheme. Woodland schemes are also operated under the RDPE and aim to develop a coordinated delivery of public benefits from England's woodlands. The EWGS scheme has a national framework but funding is allocated and grants targeted at the regional level.

The environmental benefits of agri-environment schemes have been widely monitored (see Boatman *et al.,* 2008; Stoate *et al*., 2009; Natural England, 2009; Natural England, 2013a). For example, a survey of Biodiversity Action Plan (BAP) priority grasslands showed that grasslands within agri-environment agreements were almost twice as likely to be in favourable condition as those outside agreements and that, overall, there is good evidence that UK agri-environment schemes have delivered significant benefits to biodiversity (Boatman *et al.,* 2008).

1.2.3. History of agri-environment schemes, uptake, how they work and targeting

The first agri-environment schemes were launched in England in the mid-1980s in response to land management practices (driven by subsidies that supported production) that were degrading the natural environment. The Broads Grazing Marsh Conservation Scheme launched in 1985 provided support for land management practices that protected the Halvergate Marshes in East Anglia threatened by agricultural improvement (Natural England, 2012a). The concept was then extended to five geographical areas of landscape, biodiversity and cultural importance as the first Environmentally Sensitive Areas (ESAs). A series of ESAs were then launched through the late 1980s and early 1990s, each with a suite of options supporting land management practices that enhanced the natural environmental of that specific landscape. Within these geographically defined landscapes, any landowner willing to follow the management set out in the scheme was eligible to join.

The next major change occurred with the introduction of the Countryside Stewardship Scheme (CSS) in 1991. CSS aimed to promote environmentally friendly land management practices to the wider countryside, and came with a broader remit to improve the natural beauty and diversity of the countryside through the management of landscape, wildlife habitats, historical features and public access. Over the next 15 years the schemes evolved with additional (and more specialised) schemes being introduced to cater for more specific issues, such as the Habitat Scheme and the Wildlife Enhancement Scheme (English Nature, 1996).

In 2006, the ES scheme was launched. This followed findings of the 2002 report of the Policy Commission on the Future of Farming and Food (Cabinet Office, 2002) and criticisms that, whilst the original schemes had reduced environmental damage from agricultural intensification, they had been less successful at maintaining and restoring high-quality wildlife habitats and features (Natural England 2012a). Like CSS, ES was available across the whole farmed environment. Crucially, for the first time, ES introduced an entry level tier open to all farmers in England on a non-competitive basis (named Entry Level Stewardship or ELS), for the provision of relatively simple (matrix) management across the wider countryside. A higher tier (named Higher Level Stewardship or HLS) supported targeted management on a competitive basis to high value features that required more complex management (core). Table 1-2 summarises the main differentiators of the ES scheme.

Table 1-2 Overview of the Environmental Stewardship scheme in England

Scheme	Description	Eligibility criteria	Length of scheme	Payment rate
Entry Level Stewardship (ELS)	'Broad and shallow' whole farm scheme with a range of management options, each with a points tariff	Open to all farmers. Operates a points threshold system reflecting farm size	5 years	A flat-rate payment is made per hectare of land
Organic Entry Level Stewardship (OELS)	'Broad and shallow' whole farm scheme with management options designed to recognise the environmental benefits of organic farming	Open to all organic farmers. Operates a points threshold system reflecting farm size		A flat-rate payment is made per hectare of land, plus payment to offset costs of conversion to organic farming and of maintaining organic certification
Higher Level Stewardship (HLS)	Highly targeted whole farm scheme aimed at land and features of greatest environmental value	Competitive scheme based on meeting criteria summarised in regional targeting statements. ELS or OELS is normally a prerequisite	10 years	Specific payment rates for individual management options. Also provides payments for capital works
Organic Higher Level Stewardship (OHLS)	Highly targeted 'whole farm' scheme aimed at organic farmland and features of greatest environmental value	Competitive scheme based on meeting criteria summarised in regional targeting statements. ELS or OELS is normally a prerequisite		Specific payment rates for individual options. Also provides payments for capital works

Adapted from Courtney *et al*., (2013).

Each scheme includes a suite of land management 'options', defined to ensure that there are suitable options available for all land types that are within the remit of the particular scheme. Hence, the ES scheme, as a national scheme, contains options for a wide range of habitats (e.g. from coastal saltmarsh to upland moorland). Typically, for each habitat type there are options to maintain, restore or create habitat. There are also non-habitat based options, for example, for the protection of historic features and/or resource protection.

Within each individual option, the actual land management requirements are set out in a series of 'Prescriptions', essentially a list of Do's and Do nots. These specify the nature of allowable operations (e.g. 'Do not cultivate the land'), permissible inputs ('Do not increase existing levels of fertiliser application') and timings (Do not cut the grass before 1 July').

Prescriptions can be standardised (as in the case of the ELS) or tailored to the individual agreement (as in HLS). Eligibility for payments (and penalties for non-compliance) are then based, not on achievement of environmental objectives, but on compliance with the prescriptions. Where farmers are unable to comply with a prescription they can apply for a derogation (where there is a short-term or one-off issue) or an amendment (where the inability to comply is ongoing). Compliance with scheme requirements including prescriptions is monitored by an Inspection Programme as required by the Rural Development Regulation (RDR). Where agreement holders are found to have failed to comply with scheme rules there are a range of penalties depending on the extent and degree of the infringement. These range from fines to termination of the agreement.

Differences between Environmental Stewardship (ES) and the new Countryside Stewardship scheme (CS)

In the new Countryside Stewardship Scheme, prescriptions are standardised, with the emphasis on consistent wording of individual prescriptions across the range of scheme options. Prescriptions can be edited to suit the individual agreement in the Higher Tier of the new scheme. Each individual prescription has been assessed to ensure that the management can be verified. Whilst this structure provides flexibility of option selection, the restrictions on prescriptions and focus on compliance rather than outcomes may hinder farmers' ability to adapt management to their specific conditions.

In 2015, ES was replaced by the new Countryside Stewardship scheme (CS). CS follows a similar design as ES with two tiers; a mid-tier (matrix) focused on the wider countryside and a higher-tier (core) focused on high quality features that require more complex management. Most elements of CS are competitive. Applications are scored against their ability to deliver the environmental priorities of the scheme in their local area. These local priorities are set out in the CS targeting framework (Defra, 2014) and targeting statement for each National Character Area (NCA) in England (see HM Government, 2015).

The first CSS was available across the wider countryside but was competitive. Regionally-based targeting statements identified geographic areas where applications were sought, and the range of relevant options. Individual applications were scored against their ability to deliver against the targeting statements. This scoring was then used to determine whether an agreement was offered. In practice, at least in the latter years of CSS, the level of competition was often low as the majority of interested land holdings had already joined the scheme.

The higher tier of ES developed this approach with NCA-based targeting statements. This was supported, thanks to increased availability of geographic information with a Targeting Database that brought together information on the full range of scheme objectives: biodiversity, landscape, natural resource protection, public access and historic interests. Whilst in the previous CSS, applications were assessed for their potential to achieve locally-defined scheme objectives, in HLS, the land holdings were assessed based on the significance of the environmental features on the holding (as indicated in the Targeting Database). Applications were then sought from the highest scoring landholdings.

Targeting and scoring in CS - 2015

The new CS builds on the approach used to target the higher tier of ES. Detailed targeting statements for each NCA highlight the objectives of the scheme for that area. These are supported by spatial datasets available on the MAGIC platform (see http://magic.defra.gov.uk/). As with HLS, applications are first invited and then scored on the basis of whether the proposed options (choice, amount and number) deliver the targets set for that NCA. A new element for Targeting in the new CS scheme is the ability to 'uplift' scores, where applications meet defined national objectives. Currently, these are: the Wild Pollinators & Farm Wildlife Package, water quality (where the application is endorsed by a Catchment Sensitive Farming Officer), and where the application is part of a defined collaborative working agreement.

The current approach to targeting and scoring aims to deliver climate change adaptation and mitigation through the biodiversity and water objectives; the current targeting and scoring system aims to focus the scheme towards these objectives. Higher scores are given to expressions of interest which include options that cover priority habitats, and bespoke management that supports s41 species, with an uplift (% increase) given to expressions of interest that include SSSIs. Expressions of interest that include action to promote water quality, wader and woodland bird assemblages, historic features, educational access and rare breeds are also scored positively either as a % uplift or scored directly. The scoring is logarithmic with the score based on the area, extent or number of features covered by appropriate options/management. Water quality features have been split into Phosphates, Sedimentation, Faecal coliforms, Pesticides and Flood Risk Management with each measure scored independently is appropriate action is proposed. Climate change mitigation and adaptation are not scored. Expressions of interest are ranked by the score they receive and agreements offered accordingly.

1.2.4. History of English Woodland Grant Schemes, uptake and how they work

The Farm Woodland Scheme (FWS) was introduced in 1988 to encourage farmers to plant new woodland on land formerly used for agriculture. Farmers also received planting grants from the Forestry Commission under the Woodland Grant Scheme (WGS) to cover the initial cost of establishing woodlands. Annual payments were provided to farmers approximately one year from the start of the agreement and were paid annually (for up to 40 years). In 1992 the FWS was replaced by the Farm Woodland Premium Scheme (FWPS) which provided annual payments to compensate for agricultural income foregone. Farmers were able to apply to either (WGS or FWPS) schemes. The WGS was later replaced in 2005 with the English Woodland Grant Scheme (EWGS). The EWGS incorporated a wider remit to sustain and increase the public benefits from existing woodlands and to focus investment in the creation of new woodlands in England of a size, type and location that most effectively deliver public benefits (Forestry Commission, 2012). The EWGS offered six types of grants as described in Table 1-3 below.

Table 1-3 Overview of the English Woodland Grant Scheme

Woodland	Grant type	What the grant is for
Stewardship of existing woodlands	Woodland Planning Grant (WPG)	Preparation of plans that both assist with management of the woodland and meet the UK Woodland Assurance Standard
	Woodland Assessment Grant (WAG)	Gathering of information to improve management decisions
	Woodland Regeneration Grant (WRG)	Supporting desirable change in woodland composition through natural regeneration and restocking after felling
	Woodland Improvement Grant (WIG)	Work in woodlands to create, enhance and sustain public benefits
	Woodland Management Grant (WMG)	Contribution to additional costs of providing and sustaining higher quality public benefits from existing woodlands
Creation of new woodlands	Woodland Creation Grant (WCG)	Encouraging the creation of new woodlands where they deliver the greatest public benefits, including annual Farm Woodland Payments to compensate for agricultural income forgone.

The EWGS closed to new applications in 2014 and was replaced by CS. Woodland is one of the scheme’s priorities and funding is available to create new woodland, support the preparation of management plans, address tree health issues and improve existing woodlands. As described above, CS is competitive and applications will be scored against local priority targets to maximise environmental benefit.

1.2.5. Agri-environment schemes and climate change

Climate change adaptation and mitigation have been overarching objectives of agri-environment schemes in England since the CAP health check in 2008 (Commission of the European Communities, 2008) when it was introduced as an overarching objective to the ES scheme (Natural England, 2008). It has remained an overarching objective in the new CS scheme launched in 2015. Following the addition of climate change as an overarching objective, Natural England produced a series of guidance documents to promote the uptake of ES options that would deliver adaptation and mitigation to climate change (Natural England, 2012b).

Although climate change remains an overarching objective for CS, recent documentation largely omits mention of climate change (Defra, 2015, Natural England, 2015a). The 2015 and 2016 CS manuals only mention climate change in relation to the benefits of continuous cover forestry for adaptation (see Natural England 2015a; 2016). The assumption appears to be that climate change adaptation and mitigation will be delivered through the delivery of the scheme’s other objectives, primarily those on biodiversity and water; this is reflected in the current scoring rationale where climate change does not score in its own right.

The NCA targeting statements (see HM Government, 2015) highlight the priority for action to reduce vulnerability and improve the resilience of the other scheme priorities. Unlike the other objectives of the scheme, which have priorities linked to the specific features of the NCA, the climate change text is a standard paragraph in all 149 profiles, namely:

"By choosing land management options and capital works which support the management of the vulnerable features and habitats listed in this statement, including where vulnerabilities are increased by climate change, applicants will support the resilience of biodiversity, water and other scheme priorities to the impacts of climate change, which is a cross-cutting objective of the scheme."

From: Countryside Stewardship priorities for the Border Moors and Forest (Natural England, 2015b)

Unlike the other objectives of the scheme, climate change vulnerability is not assessed and the appropriateness of adaptation measures not identified or scored for in the assessment of applications under CS. Therefore, there is a need to understand the extent to which CS fulfils the potential for agri-environment schemes to deliver on mitigation and adaptation or whether a more proactive approach could achieve more for addressing climate change. Please note, recent advances in our understanding of how climate change is impacting the natural environment have been summarised in Natural England's Adaptation Manual (see Natural England and RSPB. 2014), which is now available to land management advisors when establishing agri-environment agreements.

1.2.6. Monitoring of agri-environment schemes

1.2.6.1. Background

The need for rigorous monitoring of agri-environment schemes has been recognised since their introduction in 1987. Generally speaking, the key drivers for monitoring are to demonstrate value for money in support of public funding, to enable reporting against scheme targets at national and EU levels and to understand the effectiveness of management and to feed this back into scheme development and design (a form of adaptive management) (Mountford *et al.,* 2013).

Over time, the development and delivery of monitoring programmes has reflected the structure and objectives of individual schemes, hence strategies and detailed approaches have evolved. For example, for ESAs monitoring was tailored to the specific objectives and structure of individual areas. For CSS, where a national scheme was delivered within a framework of target landscapes, a different approach was needed. As a result, the focus of monitoring for CSS was on appraising potential and delivery (at the individual agreement level) and drawing broad conclusions about the scheme from evaluating the results of a sample of agreements as a whole.

Since then Natural England has worked with Defra to plan and deliver the ES Evidence Plan that includes the monitoring and evaluation of ES (Mountford *et al*., 2013) and more recently to develop a monitoring and evaluation plan for the new CS scheme. Over the last ~29 years of monitoring, a significant body of evidence for scheme outcomes has been collected across all scheme objectives. One of the principal drivers for monitoring now is the requirement for all EU Member States to report to the EU on the outcomes of their RDPs. The outcomes to be evaluated are specified as a suite of indicators in the Common Monitoring and Evaluation Framework (CMEF) (European Commission, 2006). Results and impacts are the primary focus of outcome monitoring; results are evaluated at the option level whilst impacts are assessed at a broader spatial scale (as options often have impacts beyond the agreements within which they are applied.)

1.2.6.2. Rationale

The evolution of the design of England's monitoring programmes has been increasingly influenced by the need to evaluate the wider contribution made by agri-environment schemes, including targets for biodiversity (e.g. the UK Biodiversity Action Plan, Bio2020 and Farmland Bird Target), water quality (Water Framework Directive) and landscapes, as well as understanding the broader contribution made to sustainable development (Mountford *et al.,* 2013). These requirements have led to the incorporation of various monitoring approaches into the ES programme, including: Integrated Site Assessments (ISA), involving condition assessments of individual SSSI units and HLS options undertaken by Natural England; Advisors Agreement Scale Assessments (ASA), involving holistic assessments of the quality of agreements and the management being delivered within them, across the range of scheme objectives; and Thematic Assessments (TA) of the effectiveness of scheme management, focussing on the delivery of particular scheme options or the impact of specific features (e.g. historic features).

Reporting effectively on the CMEF indicators requires provision of evidence for the success of management designed to provide benefits against each of the scheme objectives. Alongside this general requirement, it is also prudent to gather objective evidence that demonstrates the contribution that ES has made towards other domestic policy objectives (e.g. Bio2020 and 'Aichi' targets) in a cost-effective way (Mountford *et al.,* 2013). However, despite the comprehensive monitoring programme and targeting metrics that exists to date, there is no such framework for monitoring and/or assessing the contribution that agri-environment schemes make towards climate change adaptation.

1.3. Project aims and objectives

The overarching aim of this project therefore is to develop a monitoring protocol to improve understanding and enable assessment of how agri-environment schemes may (or may not) contribute to climate change adaptation. This project focusses upon adaptation of the natural environment.

This project has the following objectives:

1. Define a **monitoring framework** for future agri-environment monitoring that may be used in RDP reporting; and
2. Undertake a detailed spatial analysis to **develop a national baseline** from which future change is able to be compared.

The second objective will use the existing pattern of uptake of ES to develop the baseline. It will then be possible to monitor how uptake of the new CS scheme alters the current position.

A Steering Group was utilised to guide development of the project, comprising the following individuals:

- Simon Duffield (Natural England)
- Trevor Mansfield (Natural England)
- Mike Morecroft (Natural England)
- Sarah Taylor (Natural England)
- Nicholas Macgregor (Natural England)
- Russell Todd (Defra)

1.4. Structure of the report

The remainder of this report is structured as follows:

- Section 2 describes the rationale behind the development of the **monitoring framework**;
- Section 3 describes the development of the **national-scale element** of the monitoring framework;
- Section 4 presents the **results of the baseline assessment**;
- Section 5 describes the development of the **farm-scale element** of the monitoring framework; and
- Section 6 provides **discussion, a summary of findings** and a set of **recommendations**.

References and appendices are contained at the back of this report.

2. Developing a monitoring framework

This section describes the development of a monitoring framework that may be used to assess the contribution that agri-environment schemes make to climate change adaptation in England, which potentially has application to reporting under the RDPE (objective 1 – see Section 1.3). The monitoring framework is split into two elements that represent the national- (Section 3) and farm-scales (Section 5). Broadly speaking, the national-scale element provides an easily replicable, comprehensive assessment of trends and/or changes whilst the farm-scale element provides ground-truthing of the national-scale element plus the ability to assess other aspects (e.g. habitat condition, farmer attitude, delivery flexibility). Section 4 provides results of the comprehensive baseline assessment undertaken at the national-scale.

Section 2.1 that follows describes the development of the monitoring objectives.

2.1. Methods: Developing monitoring objectives

The ES (and subsequent new CS scheme) scheme has a number of objectives relating to the natural environment. These include:

- Conserving wildlife (including farmland birds);
- Maintaining and enhancing landscape quality and character by helping to maintain important features such as traditional field boundaries;
- Protecting the historic environment, including archaeological features;
- Protecting natural resources by improving water quality and reducing soil erosion and surface run-off; and
- Responding to climate change by protecting existing soil carbon levels, increasing carbon sequestration and supporting the adaptation of the natural environment to climate change.

These objectives manifest in a range of benefits provided to the environment and, at a local (farm) level, are delivered through a range of land management options available to farmers that are applied on land that they manage. In addition to these field-based options, there are 'whole farm' options, such as for educational access or support for capital items, for example improvements to farm buildings or the development of management plans. A full list of options available to land managers under both tiers (ELS and HLS) of ES is available in the associated handbooks (see Natural England, 2013b; 2013c, respectively). Due to data availability, for the purposes of this project we have focussed on field-based land management options.

More broadly, options may be separated into those that focus on the creation, maintenance or restoration of environmental features (e.g. species-rich habitat or presence of a rare species). The priority is for the maintenance of existing high-quality sites, followed by restoration and then creation. Table 2-1 provides a summary of the different types of options and some examples of options that may be applied to a range of environmental features.

Table 2-1 Types of ES options (maintenance, restoration and creation)

Initial grouping	Description	Example of an option
Maintenance	Maintenance options are usually used where features are already in good condition. The management requirements generally maintain the status quo of the feature and there is usually limited scope for enhancing the environmental interest of features.	*HP5 – Maintenance of coastal salt marsh*. Used to maintain coastal salt marsh through continuation of proactive beneficial management practices. Management includes maintaining favourable management to encourage the environmental features, not damaging the saltmarsh vegetation by disturbing the surface and retaining woody debris and accumulations of seaweed.
Restoration	Restoration options aim to improve the condition of the environmental feature(s). More positive management is usually necessary and certain activities (i.e. the movement of heavy machinery or livestock) will need to stop in order that, over time, the feature(s) of interest is/are restored. The potential for restoration is dependent upon a number of factors, including soil type and location of the land parcel in relation to existing features.	*HC8 – Restoration of woodland*. Used to restore woodlands to benefit wildlife and to protect and strengthen the local landscape character. Restoration may stipulate the exclusion of livestock, undertake planting and to protect trees from grazing damage.

Initial grouping	Description	Example of an option
Creation	Creation options are limited to circumstances where a need for habitat creation has been identified, and then only on the most suitable sites. Suitability depends on a variety of similar factors to those given for restoration. If a site is suitable, the creation options will likely require conversion to a very specific type of grassland or other habitat, and management is usually quite demanding.	*HK8 – Creation of species-rich, semi natural grassland*. This option is aimed at creating species-rich grassland on former arable land. This option is usually targeted at sites close to existing species-rich grassland. Creation of a species-rich grassland will include establishing the sward by natural regeneration or using a seed source or mixture.

Applied in isolation (or in combination), these maintenance, restoration and creation options may be used to provide a number of benefits to biodiversity for adapting to climate change.

2.1.1.1. Adaptation background

The NAP objectives (see Table 1-1) provide a conceptual framework within which we are able to understand the type of, and degree to which, adaptation to climate change is required. They also encompass how this should be achieved, in terms of the need for flexibility and an adaptive management approach that robust adaptation responses require. As climate and the natural environment vary across the country, the impact of climate change will differ from place to place. The response (adaptation) to climate change is also likely to vary by the type of farming system present in different parts of the country. Accordingly, the requirement for appropriate adaptation is likely to be place- and context-specific (Section 1.1).

Alongside this spatial dimension, adaptation to climate change should also be addressed at (and across) different spatial scales; this may allow for increased climatic vulnerability in particular places provided suitable habitats are available elsewhere within a larger, functionally connected, landscape. Lawton *et al.,* (2010) addressed this and identified a need for 'more, better and joined up' wildlife sites, which would combine as a coherent and resilient ecological network. Indeed, two of the NAP objectives (building ecological resilience to the impacts of climate change and preparing for and accommodating inevitable change) echo the importance of scale (from the national through to local scales) when considering adaptation to climate change (see Table 1-1).

Over the last decade, numerous papers have been published highlighting recommendations and actions to promote adaptation for the natural environment (e.g. Defra 2008; Heller and Zavaleta 2009; Maudesley *et al.,* 2009; Hansen and Hoffman, 2011) and these more detailed, but still relatively high-level, principles underpin the NAP objectives (Table 1-1).

Building resilience (the first NAP objective) is a well-established objective for conservation and in many cases is not climate change specific (Morecroft *et al.,* 2012). Within the literature there are a range of actions that have been proposed to promote resilience building. The protection of the most important sites, such as designated sites and priority habitats is frequently the core first step to building resilience (Hopkins *et al.,* 2007). Reducing non-climatic sources of pressure or harm to ensure that species' populations are better able to cope with the stresses from climate change has also been enshrined in many approaches, ranging from actions to address individual sources of harm (i.e. inappropriate management) through to ecosystem restoration (i.e. the restoration of naturally functioning hydrology) (Natural England and RSPB, 2014).

These measures in many cases are not climate change specific and will promote the resilience of the natural environment to any adverse impact. Within the building resilience objective actions that are more specific to climate change have also been identified relating to focusing on specific areas or feature, that are either vulnerable to climate change or likely to mitigate climate change and encourage the persistence of species or habitats (Suggitt *et al.,* 2014; Eigenbrod *et al.,* 2014; Maclean *et al.,* 2015).

As with the first NAP objective, within the second NAP objective there are a series of underpinning principles. For example, responding to the fragmentation of the remaining patches of semi-natural habitat to enable species to move through landscapes in response to climate change by creating or restoring habitat; and the need to replace habitat lost or altered by climate change help accommodate environmental change. It is also important to consider the ability of the natural environment to support adaptation and mitigation of other sectors. Accordingly, activity that promotes EbA and ecosystem-based mitigation (EbM) underpin the third NAP objective. Table 2-2 (overleaf) provides an overview of the NAP objectives and adaptation principles that support conservation.

Table 2-2 Adaptation principles for conservation based on the NAP objectives

NAP objective	Adaptation principle for conservation
Building ecological resilience	The most important sites for biodiversity will be protected
	Non-climatic adverse pressures will be reduced
	Degraded ecosystems will be restored
	The resilience of species' populations will be enhanced
	Action should focus on areas particularly vulnerable to climate change
	Areas in which species are likely to be able to persist should be protected
Accommodating change	Dispersal of species between fragmented patches will be facilitated
	Habitats/ecosystems lost to climate change should be protected or recreated elsewhere
	Action should anticipate and address possible changes in species' ranges and the composition of species assemblages
	An adaptive management approach should be used
Valuing the wider adaptation benefits	Ecosystem-Based Adaptation will be promoted
	Adaptation for the natural environment will be cost-effective
	Opportunities for Ecosystem-Based Mitigation will be realised

To help recognise trends, and to evaluate our progress towards adapting to climate change, the Committee on Climate Change (CCC) has recently produced a set of indicators as part of the UK Climate Change Risk Assessment (CCRA) (see Committee on Climate Change, 2016a). These indicators have been categorised into a series of broad themes, including agriculture and forestry and the natural environment. They provide a set of metrics by which organisations, including the CCC, are able to monitor progress made by different sectors towards adaptation. Table 2-3 provides some examples of these indicators from the UK CCRA (see Committee on Climate Change, 2016a).

Table 2-3 Examples of existing indicators from the CCRA

Theme	Impact/opportunity area	Example indicator(s)
Agriculture and forestry	Agricultural productivity	Total productivity of UK agriculture
	Forestry production	Proportion of timber trees planted in areas likely to be climatically suitable in 2050
	Water use	Total water abstraction for UK agriculture
	Water efficiency	Total on-farm water storage capacity
	Soils	Area of Best and Most Versatile agricultural land converted to development, by grade
	Livestock	Number of livestock units with ventilation systems
	Flooding	Area of Best and Most Versatile agricultural land located in areas with a high likelihood of river/coastal and groundwater flooding
	Pests and pathogens	Agricultural losses from pests/pathogens
Natural environment	Changes to climate space	Area of SSSIs in an unfavourable condition, by habitat type Area of Priority Habitats classed as fragmented or isolated
	Peatlands	Area of degraded deep peat habitats being restored
	Freshwater habitats	Number of SSSI freshwater sites with amended management objectives in response to changing climatic conditions
	Coastal habitats	Proportion/area of inter-tidal/supra-tidal SSSIs in unfavourable condition, by habitat type

2.1.1.2. Identifying adaptation indicators and indicators for monitoring

The adaptation context discussed above, coupled with our understanding of the broader environmental benefits provided by agri-environment schemes more generally (see Section 1.2.3), means that we are able to make informed judgements about the types (and extent) of adaptation that we might expect agri-environment schemes to be delivering. Consequently, this section describes the rationale behind the development of a set of adaptation indicators on which to base a monitoring framework. Notably, the indicators are provided in the style of hypotheses that may be tested. The outcomes of these indicators describe the types of adaptation for the natural environment that we might expect to be delivered by agri-environment schemes.

Using the NAP objectives (see Table 1-1) and adaptation principles (see Table 2-2) a series of environmental objectives for agri-environment schemes were identified (Table 2-4). Each objective aimed to promote adaptation for the natural environment, EbA (using the natural environment to support adaptation in other sectors) or ecosystem restoration and EbM. Two additional outcomes focusing on ways of working were also developed.

Table 2-4 Broad adaptation-focused adaptation indicators for agri-environment schemes, grouped under the adaptation principles and NAP objectives to which they relate

NAP objective	Adaptation principle	Broad adaptation indicator for agri-environment schemes
Building ecological resilience	The most important sites for biodiversity will be protected	Maintenance and restoration options will focus on priority habitats
		Areas under agri-environmental management will have greater improvements in condition than those not under management
		Agri-environment schemes will support protected areas
	Non-climatic adverse pressures will be reduced	Agri-environment options (particularly creation options) will reduce fragmentation and enhance ecological networks
	Degraded ecosystems will be restored	Creation and restoration options will be focused within areas of highest potential for restoring ecosystems
	The resilience of species populations will be enhanced	Creation options around existing habitats will create larger conservation sites that have more 'core' to 'edge' habitat and support larger and more resilient populations
		Creation options increase the topographic heterogeneity of habitats to create a wider variety of microclimates
	Action should focus on areas particularly vulnerable to climate change	Restoration and maintenance options will support highly sensitive habitats
	Areas in which species are likely to be able to persist should be protected	Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia
Accommodating change	Dispersal of species between fragmented patches will be facilitated	Matrix options to restore or create features should be focussed in areas of high fragmentation
	Habitats/ecosystems lost to climate change should be protected or recreated elsewhere	Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)
	Action should anticipate and address possible changes in species' ranges and the composition of species assemblages	Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions
		Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations
	An adaptive management approach should be used	Agri-environment scheme options should be applied in a flexible way and accommodate change where appropriate
Valuing the wider adaptation benefits	EbA will be promoted	Agri-environment options will help to reduce climate-related flood risk and water pollution; appropriate options will be spatially targeted to achieve this
	Adaptation for the natural environment should be cost-effective	Agri-environment options (particularly creation options) will be targeted on areas that give the greatest environmental benefit per area of land taken out of production
	Opportunities for EbM will be realised	Agri-environment schemes will contribute to the storage and sequestration of carbon

These broad outcomes were then regrouped and developed into a more specific set of adaptation indicators for monitoring purposes (see Table 2-5 overleaf).

Table 2-5 List of adaptation indicators

Category	Adaptation indicator
A. Protecting the most important and vulnerable sites	A1. Maintenance and restoration options will be coincident with priority habitats
	A2. The condition of priority habitat under agri-environment management will be higher than that of priority habitat not under management
	A3. Agri-environment schemes will support SSSIs
	A4. Restoration and maintenance options will support highly sensitive habitats
	A5. Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)
	A6. Agri-environment management will create shade for rivers where this is a priority for the freshwater habitat
B. Reducing fragmentation and enhancing ecological networks	B1. Creation options will reduce fragmentation
	B2. Restoration options will support the reduction of fragmentation
	B3. Woodland creation options will help to reduce woodland fragmentation
	B4. Woodland restoration and maintenance options will support the reduction of woodland fragmentation
	B5. Matrix options to restore or create features should be focused in areas of high fragmentation
	B6. Creation options will enhance ecological networks
	B7. Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species
C. Protecting refugia	C1. Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia
D. Planning for potential changes in species' ranges and assemblages	D1. Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions
	D2. Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations
E. Restoring ecosystems	E1. Creation and restoration options will be focused within areas supporting the Outcome 1D objective
F. Making species populations more resilient	F1. Creation options around existing semi-natural areas will create larger conservation sites
	F2. Creation options increase the topographic heterogeneity of habitats
G. Improving water quality and reducing flood risk	G1. Matrix options for soil protection will be focused in Water Quality Priority Areas
	G2. There will be a greater concentration of relevant agri-environment schemes options within flood prone areas to reduce flood risk
	G3. Agri-environment schemes will support the objectives of the Woodlands for Water programme
H. Storing and sequestering carbon	H1. Agri-environment schemes contribute to the storage and sequestration of carbon
I. Targeting and applying interventions in a cost-effective and adaptive way	I1. Adaptation in the natural environment will be consistent with agricultural adaptation.
	I2. Options will be implemented in a flexible way to facilitate adaptive management
	I3. Agri-environment options will accommodate change where appropriate

The remainder of this section outlines the rationale for each of the indicators identified in Table 2-5 above and describes them in more detail. For each, a confidence level is also provided which represents our level of confidence that a clear objective/indicator (and/or evidence is available in the literature to support the development of the objective/indicator) can be developed for agri-environment schemes, where:

High	A clear objective/indicator can be developed/the literature is well developed;
Medium	An objective/indicator may be able to be developed/the literature is developed; and
Low	Unlikely that an objective/indicator can be developed/the literature is developing (more work is needed).

A. Protecting the most important and vulnerable sites

Indicator A1: Maintenance and restoration options will be coincident with priority habitats

As noted above, protecting existing important areas and patterns of biodiversity is an essential foundation of adaptation for the natural environment (Mitchell *et al*., 2007; Heller and Zaveleta, 2009; Stein *et al.,* 2013; Schmitz *et al*., 2015). 'Priority habitats', as identified under the UK BAP (2007), cover a wide range of semi-natural habitat types that have been identified as being the most threatened and requiring conservation effort (JNCC, 2016a). They thus represent an extremely important series of areas to protect from the impacts of climate change.

Table 2-6 RAG assessment (indicator) – Adaptation indicator A1

Level of confidence in the indicator	Justification
High	There is a strong evidence base in the scientific literature for the protection of existing important areas for biodiversity being a fundamental first step in adaptation. There is also strong evidence that priority habitats represent many of the most important areas for biodiversity.

Indicator A2: The condition of priority habitat under agri-environment management will be higher than that of priority habitat not under management

Sites in better condition are more likely to be more resilient to climate change. It is important to be able to evaluate whether agri-environment scheme management interventions (or indeed any conservation management) are improving site condition and having an impact beyond what would happen in the absence of management. This also links to indicator I1 (on cost-effectiveness) in that Defra needs to be able demonstrate that agri-environment schemes represent conservation money well spent.

Table 2-7 RAG assessment (indicator) – Adaptation indicator A2

Level of confidence in the indicator	Justification
High	There is a strong evidence base in the scientific literature for the protection of existing important areas for biodiversity being a fundamental first step in adaptation; and strong evidence that priority habitats represent many of the most important areas for biodiversity.

Indicator A3: Agri-environment schemes will support SSSIs

The preservation and maintenance of a protected area network remains at the forefront of the regulatory responses to adaptation (Heller and Zavelata, 2008; Gauzere *et al.,* 2016). Recent evidence has demonstrated that protected areas have a positive role is prolonging the persistence of species at the trailing edge of their range (Gillingham, 2014; Suggitt *et al*., 2014), and in supporting the colonisation of species at the leading edge of their range expanding under climate change (Gillingham *et al*., 2015; Thomas *et al*., 2012). SSSIs (and other protected areas) represent core areas that form the heart of our ecological network, they are the basic building blocks of site-based nature conservation legislation in the UK and these sites usually contain our most important, and sometimes vulnerable, species and habitats (Thomas and Gillingham, 2015). There are legal responsibilities associated with maintaining specific interest features, and any threat that climate change poses to these needs to be carefully assessed. Sites can acquire new interest features through climate change as well as losing existing ones. Studies have shown that SSSIs (and the alike) are likely to remain important areas for wildlife (Natural England and RSPB, 2014). Agri-environment schemes are targeted to support these areas of core habitat and, as a result, we would expect to find options that support the maintenance and restoration of core habitats to be coincident with SSSIs and being applied in an effective way to support the conservation objectives of each site.

Table 2-8 RAG assessment (indicator) – Adaptation indicator A3

Level of confidence in the indicator	Justification
High	Protecting existing important wildlife sites is an essential first step in adaptation. SSSIs represent some of our best wildlife sites.

Indicator A4: Restoration and maintenance options will support highly sensitive habitats

Sensitivity is an important element of vulnerability and one in which some generalisations can be made at a national level. Sensitivity is defined as the degree to which a system is affected, either adversely or beneficially, by climate variability or change (Natural England, 2014); it is an inherent feature of a habitat or species as opposed to exposure which varies from place to place. Understanding the inherent sensitivity of habitats to climate change can help us identify action to build resilience and we should focus action on areas that are particularly sensitive and therefore vulnerable to climate change.

In 2014, Natural England and the RSPB developed a comprehensive assessment of 34 priority habitats and their sensitivity to climate change (ranked high to low) (Natural England and RSPB, 2014). Highly sensitive habitats were deemed to be those habitats whose existence is dependent on specific climatic, hydrological or coastal conditions, which projections indicate will change with climate change (e.g. coastal saltmarsh, lowland fen etc.). The low sensitivity habitats are those which are determined by other factors, such as grazing or geology, or more generalist species, and where climate plays only a minor role (e.g. deciduous woodland, lowland calcareous grasslands etc.). The National Biodiversity Climate Change Vulnerability Assessment (NBCCVA) also used habitat sensitivity as a metric to derive overall vulnerability for a range of priority habitats (see Natural England, 2014). These studies of sensitivity are important to assist prioritisation and planning for biodiversity adaptation, including the planning of ecological networks, landscape-scale habitat creation and management planning.

Table 2-9 RAG assessment (indicator) – Adaptation indicator A4

Level of confidence in the indicator	Justification
High	The observed impacts of climate change on habitats and species highlight that there is a range of sensitivity to climate change; we are able to differentiate to some extent those habitats that are highly sensitive from those that are less sensitive. Ensuring highly sensitive habitats are under appropriate maintenance and restoration options will improve their resilience, but they are still likely to face change.

Indicator A5: Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)

Building on the rationale for indicator A4, habitats most sensitive to climate change are likely to be adversely affected and so lost or altered. Action should therefore focus on recreating highly sensitive habitats to compensate for losses elsewhere.

Table 2-10 RAG assessment (indicator) – Adaptation indicator A5

Level of confidence in the indicator	Justification
High	The observed impacts of climate change on habitats and species highlight that there is a range of sensitivity to climate change; we are able to differentiate to some extent those habitats that are highly sensitive from those that are less sensitive. Habitats that are highly sensitive to climate change are likely to be lost or altered, ensuring that these habitats are the focus of creation activity will help balance habitat loss.

Indicator A6: Agri-environments scheme management will create shade for rivers where this is a priority for the freshwater habitat

An important element of building resilience will be maintaining suitable habitats for species as the climate changes. In 2012, the Environment Agency undertook a study to identify opportunities for creating shade over rivers using trees and vegetation (riparian shading) (see Environment Agency, 2012). The focus was on maintaining suitable freshwater habitat for salmon and brown trout (salmonid) populations that we expect to be at risk from the effects of climate change (Environment Agency, 2007). The project delineated narrow corridors, located within close proximity to rivers, which may represent opportunities for creating shade.

Historically, natural rivers, streams and their floodplains across the UK were more densely wooded and woody debris would have been a common feature in many river channels, making an important contribution to ecosystem function and provision of habitat for species (Peterken and Hughes, 1995; Mainstone *et al*., 2016). Much of this tree and vegetation cover has been lost due to changes in land use, in particular agriculture. Riparian trees and vegetation can help to reduce local water temperatures on hot summer days and the increase of bank-side flora may also provide a source of woody debris. The latter is beneficial for a range of species of plants, invertebrates and fish who feed from the reserve of food collected by the debris. Other wildlife, including otters, may also select the sites for resting (Godfrey, 2003).

A number of agri-environment options (and EWGS grants) contribute directly to the restoration and creation of new woodland habitats (including restricting livestock movements, management of wood edges and establishment of hedgerows) and therefore may contribute to the objectives of the Keeping Rivers Cool programme (Environment Agency, 2012). However, it is worth noting that given the relatively narrow areas that these corridors cover (along river banks), coupled with the spatial representation of agri-environment scheme data used in this project (represented as centroids of the agreement area), it is unlikely that there will be sufficient overlap between these two datasets in order to compare the location of restored and/or newly created areas of woodlands with riverine shading.

Table 2-11 RAG assessment (indicator) – Adaptation indicator A6

Level of confidence in the indicator	Justification
Medium	While there are many options suitable for restoring existing woodland habitats and creating new areas of woodland, it is unlikely that these areas will correspond to those areas identified in the Keeping Rivers Cool project.

B. Reducing fragmentation and enhancing ecological networks

The summary that follows provides a definition of habitat fragmentation and ecological networks. It is presented here to reduce repetition in this section and in the individual sections which follow.

Habitat fragmentation refers to the breaking up of larger areas of habitat into smaller pieces. It is distinct from (but often occurs in parallel with) habitat loss i.e. a reduction in the overall amount of natural land cover. The broad process of 'fragmentation' can have a number of distinct though linked effects that can often have serious consequences for ecosystem function and the biodiversity and ecosystem services it supports (Fahrig, 2003; Opdam and Wascher 2004; Fischer and Lindenmayer, 2007; Lindenmayer, 2009). These include:

- Subdivision of species' habitat into smaller patches, some of which might be too small to continue to support populations of a species, or to maintain stable/viable populations (or metapopulations across multiple sites) in the long-term;
- Isolation of habitat patches and reduction of successful species immigration and emigration. This can increase the likelihood of inbreeding and loss of genetic diversity, and of local population extinction through chance events (combined with a decline in the likelihood of re-colonisation). This could become an increasingly serious issue as the climate continues to change and populations in isolated patches are both at higher risk of being affected by extreme events and unable to shift as their suitable climatic environment 'moves';
- 'Edge effects' – environmental changes that occur at the boundary between one type of land cover and another (for example disturbance from a human-modified area affecting an adjacent patch of semi-natural vegetation). These can include both biotic and abiotic effects, such as structural damage or change to vegetation; changed temperature, light and evaporation levels; altered nutrient cycling; the deposition of fertilisers and pesticides; changed patterns of plant growth, and increased effects of predators and invasive species. Some of these effects can penetrate a long way into a patch; and
- Impaired function of some ecosystem processes, such as hydrological flows. This can affect the stability and viability of the system and not only its capacity to provide habitat for species (as outlined above) but also the services it provides to people.

A recent review by Haddad *et al*., (2015) highlights how great an impact fragmentation has had on natural ecosystems. Moreover, the information presented in the Making Space for Nature report (Lawton *et al*., 2010) emphasises just how small and fragmented most of the remaining patches of semi-natural land cover in England are. Among the figures quoted in the report (and other recent publications):

- Seventy-seven percent of SSSIs and 98% of Local Wildlife Sites are smaller than 100 ha;
- For several BAP priority habitats the median patch size remaining is smaller than 2 ha; and
- In 90% of cases, these patches of land are under 100 ha.

Having small sites means there is lots of ‘edge’ and little ‘interior’. For example, a recent study of forest patches in England (Riutta *et al*., 2014) found that 37% of forest is within 30 m and 74% within 100 m of the nearest edge. For ancient woodlands, 28% and 62% of the area was within 30 m and 100 m respectively of the nearest open edge (see also Watts, 2006).

England’s fragmented landscapes make species and ecosystems much more vulnerable to the effects of climate change. Reversing the effects of fragmentation would make biodiversity more resilient (e.g. Morecroft *et al*., 2012; Newson *et al*., 2014; Oliver *et al*., 2015) and is therefore an essential component of adaptation.

The concept of **ecological networks,** and a consequent need to work at large scales beyond individual sites, has increasingly been recognised as a priority for nature conservation (Lawton *et al*., 2010). An ecological network comprises a suite of high quality sites which collectively contain the diversity and area of habitat that are needed to support species and which have ecological connections between them that enable species, or at least their genes, to move (Lawson *et al.,* 2010). These networks are reflected in the NAP in the context of building ecological resilience through reducing the adverse impacts of climate change (Defra, 2013). Lawton *et al*., (2010) advocated the need for coherent and resilient ecological networks of sites. A key aspect of this ‘landscape’ approach is increasing the number, size and cumulative area of semi-natural habitat patches and making the surrounding landscape more suitable for wildlife (Natural England and RSPB, 2014) and increasing the functional connectivity of a landscape (i.e. the extent to which it supports movement of a species).

Habitat networks therefore need to be considered at multiple biological scales:

- To join fragments to create larger sites supporting larger populations;
- To restore functional connections between sites to improve inter-site movement of species (increasing the chances of recolonisation if the population in any site is reduced as the result of climate change-related extreme events); and
- To enable longer-distance movement by species to facilitate range shifts as climatic conditions change.

The first of these scales is a vital foundation for the other two – it is important that networks are built around core areas of high nature conservation value which are sufficiently large and of sufficiently high quality to support large populations in which species have the greatest possible chance of persisting if conditions become unsuitable, and from which individuals can disperse. Such areas will also be essential for ecosystem function and provision of ecosystem services. Core sites would generally have the highest concentrations of species or support rare species and include protected wildlife sites and other semi-natural areas of high ecological quality (Lawton *et al*., 2010). Without appropriate core areas, it is arguable that much conservation work in the wider landscape will have reduced benefit.

Agri-environment schemes have an important part to play in addressing all aspects of fragmentation and supporting ecological networks at various scales. We would expect options that support the creation of habitats (e.g. priority habitats or woodlands) to be applied close to existing core areas of habitat thereby improving the functional connectivity of the landscape. In addition, many of the smaller-scale management options that agri-environment schemes can deliver have the potential to play an important role in ‘softening the matrix’ of agricultural land between conservation sites. Skirvin et al., (2014) carried out a detailed literature review on the use of ES for restoring, maintaining and enhancing a coherent ecological network in England. They concluded that the priorities for action should be to:

1. Increase patch quality (availability of resources within a patch);
2. Increase patch size; and
3. Increase links between patches.

They noted that, although the relative priority of management actions will usually be as listed above, increasing any of these three will always be beneficial to metapopulation persistence. A number of tools have been developed recently to investigate habitat fragmentation and identify priorities for restoration (e.g. Watts, 2006; Taylor *et al*., 2011; Condatis, 2016); these can be used to inform targeting of appropriate agri-environment options.

Indicator B1: Creation options will reduce fragmentation

Options that support the creation of habitats (e.g. priority habitats or woodlands) would be expected to be applied close to existing core areas of habitat thereby improving the functional connectivity of the landscape.

Table 2-12 RAG assessment (indicator) – Adaptation indicator B1

Level of confidence in the indicator	Justification
High	Addressing habitat fragmentation is a crucial part of adaptation and the benefits of supporting core areas of habitat are well acknowledged. Agri-environment schemes should be concentrated on these areas to support core habitat.

Indicator B2: Restoration options will support the reduction of fragmentation

This adaptation indicator is almost identical to indicator B1 except that it focuses on restoration and maintenance options, rather than creation options. The rationale is therefore similar, such that to build ecological resilience we need to ensure that we focus our restoration effort to develop a suite of high quality sites that are able to support rare species and habitats. We may therefore expect to find options that support the restoration of habitats to be applied within existing areas of core habitat.

Table 2-13 RAG assessment (indicator) – Adaptation indicator B2

Level of confidence in the indicator	Justification
High	Addressing habitat fragmentation is a crucial part of adaptation, and the benefits of supporting core areas of habitat are well acknowledged. Agri-environment schemes should be targeted to support these areas of core habitat through restoring and maintaining existing semi-natural areas.

Indicator B3: Woodland creation options will help to reduce woodland fragmentation

As for indicator B1 but specific to woodland.

Table 2-14 RAG assessment (indicator) – Adaptation indicator B3

Level of confidence in the indicator	Justification
High	Better core areas of woodland are needed. Agri-environment schemes should be targeted to support these areas.

Indicator B4: Woodland restoration and maintenance options will support the reduction of woodland fragmentation

As for indicator B2, but specific to woodland.

Table 2-15 RAG assessment (indicator) – Adaptation indicator B4

Level of confidence in the indicator	Justification
Medium	Many of England's landscapes have many small, often low quality, patches of woodland. Agri-environment scheme management can help to improve and expand these patches to provide effective core areas for woodland species. However, the effectiveness on the reduction of fragmentation is less certain and therefore may be difficult to analyse as part of a national-scale assessment.

Indicator B5: Matrix options to restore or create features should be focused in areas of high fragmentation

Alongside supporting core areas of habitat, evidence suggests that to improve functional connectivity of the landscape that a general softening of the matrix or increasing permeability of the landscape (i.e. increasing its quality through inclusion of a greater proportion of non-crop habitats), using agri-environment schemes, should lead to improved connectivity (and therefore a reduction in habitat fragmentation) (Lawton *et al.,* 2010; Donald and Evans, 2006).

Semi-natural and extensive habitats are generally considered to be more conducive, or permeable, to species movement whilst intensive land uses are regarded as less permeable thereby reducing connectivity and effectively increasing ecological isolation. This is also supported by Eycott *et al.,* (2010; 2012) in their review of species movements which showed that species preferred to move through landscape matrices with a similar structure to the habitat patches and were more likely to leave patches if the surrounding landscape had a similar structure. Therefore, we may expect options that support matrix features to restore or create new habitat (i.e. buffer strips, seed mixtures or hedgerow restoration to name a few) to be focussed in areas of high fragmentation to support improvements in functional connectivity and permeability of the landscape.

Table 2-16 RAG assessment (indicator) – Adaptation indicator B5

Level of confidence in the indicator	Justification
Medium	While theories supporting improvements in functional connectivity through increasing permeability of the landscape are well evolved, and agri-environment options have a clear role to play in improving permeability to species of agricultural areas, it is not necessarily straightforward to make simple recommendations about the sorts of landscapes in which matrix options should be situated. In extremely fragmented landscapes, where there is insufficient core habitat for a given species, or no other site for it to disperse to from its current locations, matrix options might have limited value. They might be most effective therefore in landscapes of intermediate levels of fragmentation in which there is a reasonably good set of habitat patches but little semi-natural land cover between them.

Indicator B6: Creation options will enhance ecological networks

As noted above, targeting conservation action to create and enhance resilient ecological networks is an important way of increasing the resilience of the natural environment to climate change, and will help to allocate limited conservation resources in a cost-effective way.

Table 2-17 RAG assessment (indicator) – Adaptation indicator B6

Level of confidence in the indicator	Justification
High	Addressing habitat fragmentation is a crucial part of adaptation. The benefits of creating or enlarging habitat patches in areas that are assessed as being highly fragmented are well acknowledged. Agri-environment schemes should be targeted to reduce fragmentation of habitat patches in areas assessed as being highly fragmented.

Indicator B7: Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species

As for B6 but specific to woodland.

Table 2-18 RAG assessment (indicator) – Adaptation indicator B7

Level of confidence in the indicator	Justification
High	Addressing habitat fragmentation is a crucial part of adaptation. The benefits of creating or enlarging habitat patches in areas that are assessed as being highly fragmented are well acknowledged. Agri-environment schemes should be targeted to reduce fragmentation of woodland habitat patches in areas assessed as being highly fragmented.

C. Protecting refugia

Indicator C1: Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia

As the climate continues to change, it is likely to that geographic patterns in climate suitability for many species (and their habitats) will change. To address this, ecological networks need not only to support movement across landscapes but also to enhance the resilience of species' populations and increase their chances of persisting in situ. One potentially important aspect of this is to identify and protect potential refugia: places that, as a result of having microclimates that are unusually stable or different from those of the surrounding landscape, would enable species to persist despite climate change making the surrounding area unsuitable. Such places would also facilitate dispersal and range shifts.

Refugia are a well-established feature of the last glaciation, harbouring many of the species occupying England today that have adapted to relatively warmer climates. There is increasing evidence the refugia concept is equally valid under current climate change. In a Natural England research project with the University of Exeter and other partners, the survival and extinction of over 1,000 species that retracted their range over the past 40 years was modelled against environmental characteristics (such as geology, elevation, water availability, exposure to solar radiation) thought likely (from a literature review) to influence refugium potential (Suggitt *et al.,* 2014). The models also included agricultural intensity and level of recent climatic change. The results indicated that:

- Local extinctions have been higher in areas of England that have experienced greater climatic change. This is further evidence that recent climate change is already affecting species; and
- Regional variation in topographic features influencing microclimate appears to have enhanced the persistence of a broad range of species in these areas. Refugia appear to exist under current climate change, just as they did in past glacial/interglacial cycles (Suggitt *et al*., 2014).

Mapping the locations of areas with features that were shown to be important in the analysis has enabled the refugium potential of different locations to be estimated. We might therefore expect that agri-environment options, particularly those involving major creation, restoration or maintenance of semi-natural land cover, to be targeted at protecting areas of high refugium potential.

Table 2-19 RAG assessment (indicator) – Adaptation indicator C1

Level of confidence in the indicator	Justification
Medium	Evidence for the existence of potential climate change refugia are well described in the literature but how to maximise their potential in the context of agri-environment schemes is less well understood.

D. Planning for potential changes in ranges and assemblages of species

There is clear evidence that climate change is already leading to changes in the distributions of species. In particular, many species across a wide range of taxonomic groups now occur further north in England (Morecroft and Speakman, 2013). This is certain to continue as the climate continues to change. Different species are likely to be affected in different ways – the distributions of some might not change much at all; the distributions of others (particularly species adapted to warmer conditions that are at the northern limit of their range in England) might expand their ranges; while a third group (species at the southern limit of their range and adapted to colder conditions (for example some species found at high altitudes) might suffer contractions in their ranges. A study of over 3000 species conducted by BTO, Natural England and other partners (Pearce-Higgins *et al.*, 2015a) has provided the most comprehensive assessment to date of how areas of suitable climate for different species might change in space, and which species might be at risk or potentially benefit as a result.

Changing species distributions could have a range of implications for conservation; the assemblage of species in a particular area might change and management need to be adjusted accordingly; the relative conservation priority of a species might go up or down; and broad patterns of movement might make some areas of the country a higher priority for conservation in the future. Planning of conservation, including of agri-environment schemes, should begin to take this into account. This is an example of the second NAP objective, accommodating change.

Indicator D1: Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions

Conservation management can never be applied to more than a small percentage of the land area, and therefore needs to be carefully targeted on the most important places. As noted above, changes in species distributions might change the relative conservation importance of some locations. It is important to note that places that are currently of high importance for conservation of biodiversity are likely to remain important regardless of climate change for a variety of reasons:

- They often have characteristics (soil, topography, hydrology) that will continue to support high biodiversity even if some existing species leave and new ones arrive;
- In many cases they will have microclimatic conditions that might provide refugia, enabling a species to persist in that location despite (projections of) changing climate suitability at the regional scale; there are management options that can be used to maximise this potential for in-situ conservation (Greenwood *et al*., 2015); and
- Even when a species is likely to be lost from a location in the long-term, protection of existing populations for as long as possible will in many cases be crucial to support dispersal to new locations. What could change, however, is that some places that are relatively unimportant for conservation might become more important as climatic conditions change.

Systematic conservation planning techniques (Margules and Pressey, 2000) can be used to identify the highest priority areas for protecting a suite of species or other environmental assets (e.g. Franco *et al*., 2009, Smith *et al*., 2009). Research by the University of York and Natural England, based on the models developed in the study by Pearce-Higgins *et al*., (2015a), is exploring how these methods could be used to identify the areas of highest conservation priority under projected climate change.

Table 2-20 RAG assessment (indicator) – Adaptation indicator D1

Level of confidence in the indicator	Justification
Low	Systematic conservation planning techniques that identify high priority areas for conservation based on the principle of complementarity (i.e. areas that together would protect the greatest number of species) are well developed and tested. Recent research applying these techniques to new models of climate suitability for species enables us to make some tentative conclusions about areas that will become a higher conservation priority under projected changes in climatic conditions across England. However, it is hard to make precise predictions.

Indicator D2: Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations

The relationship between many species' current range and climate implies that climate change will lead to changes in distribution and subsequent changes in species assemblages. This will vary from place to place depending on relative levels of new species colonising and existing species persisting or moving. Different action from site to site might therefore be need. This has been explored in a study by Hole *et al*., (2011) of the Important Bird Area (IBA) network in sub-Saharan Africa. They considered adaptation strategies for individual sites based on projections of changes in the relative proportions of emigrants (species for which a site becomes climatically unsuitable), colonists (species for which a site becomes climatically suitable), and persistent species (species able to remain within a site despite the climatic change). On that basis, they allocated each site to one of four categories, identifying a range of different strategies that might be required (see Table 2-21).

Table 2-21 Summary of the approach used by Hole *et al*., (2011)

Site category	Proportion of emigrating species	Proportion of colonising species	Proportion of persisting species	Suggested site management strategy
High persistence	Low	Low	High	Resilience: maintain viable populations of persistent species
Increasing specialisation	High	Low	Low	Resistance: maximise populations of projected emigrants to maximise likelihood of successful establishment in newly suitable sites
High turnover	High	High	Low	Resistance and facilitation: maximise populations of projected emigrants; facilitate transformation

Site category	Proportion of emigrating species	Proportion of colonising species	Proportion of persisting species	Suggested site management strategy
				of habitats to support projected colonists
Increasing value	Low	High	high	Resilience and facilitation: maintain viable populations of persistent species; facilitate transformation of habitats to support projected colonists

For each of these categories, Hole *et al.,* (2011) also gave examples of how the details and relative priority of different management categories such as habitat restoration, managing disturbance regimes, translocation, increasing site extent and matrix management might vary.

The study by Pearce-Higgins *et al.,* (2015a) mentioned above provides an analysis of how suitable climate space for more than 3000 species might change and therefore how their ranges *might* move as a result; it could provide a solid basis for applying, to English/UK conservation sites, a similar approach to that taken by Hole *et al*., (2011). However, a number of factors are likely to influence a species' distribution, notably the availability of habitat within the new climatically suitable area(s), the ability of the species to move to newly suitable areas, and the possible presence of refugia at different scales that might enable persistence even with a part of the current range that is expected to be vacated. This limits our ability to make firm predictions about how assemblages at individual sites might change.

Table 2-22 RAG assessment (indicator) – Adaptation indicator D2

Level of confidence in the indicator	Justification
Medium	Conceptually, there would be great value in identifying how the relative proportions of emigration and immigration of different taxonomic groups might vary across sites, and to adjust management goals accordingly. However, making such predictions is difficult.

E. Restoring ecosystems

Indicator E1: Creation and restoration options will be focused within areas supporting the Outcome 1D objective

The UK's role as a signatory of the CBD means that it is committed to a range of targets (as outlined in Table B-1 in Appendix B). Outcome 1D commits the UK to restoring at least 15% of degraded ecosystems as a contribution to climate change mitigation and adaptation (Defra, 2011). The outcome reflects the vital contribution healthy, functioning ecosystems can play in mitigating climate change and helping society and nature adapt to impacts such as flooding and sea level rise.

The approach of restoring degraded ecosystems for climate change benefits under outcome 1D focuses primarily on restoring ecosystem functions and processes. The addition of habitat or adjustment in land use in the surrounding area will also help reduce the vulnerability to climate change of existing habitat along with restoring components of the wider ecosystem.

In 2014, Natural England commissioned a study to identify areas of habitat potential for different priority habitats (including blanket bog, coastal saltmarsh, coastal sand dune, coastal vegetated shingle, fen, lowland raised bog and reedbed) that may contribute to meeting this target and aid in the spatial targeting of agri-environment options (see Amec, 2013). Therefore, we may expect creation and restoration options to be coincident with relevant habitat potential areas.

Table 2-23 RAG assessment (indicator) – Adaptation indicator E1

Level of confidence in the indicator	Justification
High	The benefits of ecosystem restoration to climate change adaptation and EbA are well grounded. The restoration of ecosystem function reduces non-climatic adverse pressures thereby improving the resilience of the system to climate change and other adverse drivers.

F. Making species populations more resilient

Indicator F1: Creation options around existing semi-natural areas will create larger conservation sites

As noted above, for ecological networks to be effective they need to be based on a core set of high quality sites of sufficient size. In general, there are many ecological advantages to making conservation sites larger, all of which will support adaptation goals. These advantages include:

- Being likely to support larger populations of species, which will also be more likely to survive unfavourable conditions and provide source populations for dispersal during good conditions;
- Supporting better functioning ecosystem processes, in turn providing niches for a wider range of species and so supporting more complex and resilient food webs;
- Being likely to contain a greater variety of land cover and resources, so providing habitat to a wider range of species;
- Being more likely to support species that need large areas of habitat;
- Providing places for colonising species to settle; and
- Providing a greater range of microclimates and reduced edge effects, increasing the resilience of resident species to events such as drought.

The Lawton review (Lawton *et al.,* 2010) identified several actions to promote coherent ecological networks, including the requirement to make existing core areas larger. From a climate change perspective, evidence is building to suggest that making sites larger will promote resilience, both in terms of making sites less prone to extreme events such as drought (Angelini and Sillman 2012; Newson *et al.,* 2014), or to colonisation by non-native invasive species (Knight *et al.,* 2014). Evidence is also increasing on the importance of the close proximity of habitat to the restoration success of created patches (Woodcock *et al.,* 2015). We therefore expect options that support the creation of habitats to be applied close to or abutting existing core areas in a way that will make functionally larger sites.

Table 2-24 RAG assessment (indicator) – Adaptation indicator F1

Level of confidence in the indicator	Justification
High	There are many clear adaptation benefits to having larger conservation sites. Agri-environment schemes are well-placed to support these areas of core habitat.

Indicator F2: Creation options increase the microclimate heterogeneity of habitats

Maintaining or increasing the heterogeneity by creating habitat over a range of topographic features, soil types will provide a greater range of microclimates. This in turn will increase the resilience of sites to climate change (Natural England and RSPB, 2014). Creation options would therefore be expected to increase the topographic range and variability where habitats are located. However, establishing the degree to which agri-environment schemes support (or not) changes in topographic range and variability is less clear.

Table 2-25 RAG assessment (indicator) – Adaptation indicator F2

Level of confidence in the indicator	Justification
Medium	The benefit of topographic heterogeneity for promoting the persistence of species under climate change has been demonstrated. Creation options can be used to increase the range of topography covered thereby increasing the range and availability of microclimate. However, establishing the degree to which agri-environment schemes support (or not) changes in topographic range and variability is less clear.

G. Improving water quality and reducing flood risk

Indicator G1: Matrix options for soil protection will be focused in Water Quality Priority Areas

An important aspect of building resilience is through changes in water quality. The issue of water quality has increasingly become an important objective of agri-environment schemes, primarily due to the UK's obligations to meet Water Framework Directive (WFD) targets (Defra, 2011). Water quality issues are best tackled at the landscape scale where coordination, in respect of scheme uptake and the selection of appropriate management options, is crucial in achieving improvements in water quality (Boatman *et al.,* 2008). Options that support the matrix, such as the use of buffer strips, in-field grasslands to reduce run-off and managing (fertiliser) inputs, will help to improve water quality through reducing diffuse pollution inputs.

Natural England and the Environment Agency have produced a dataset that identifies land areas that represent the greatest opportunity for improving water quality; this dataset has been used in targeting agri-environment schemes under CS. The areas have been scored based on seven different water quality issues including groundwaters and rivers at risk from nitrate pollution, groundwaters and rivers at risk of pesticide pollution, faecal indicators, sediment risks and phosphate risks. We may therefore expect to find options that contribute towards soil protection within these Water Quality Priority Areas.

Table 2-26 RAG assessment (indicator) – Adaptation indicator G1

Level of confidence in the indicator	Justification
Medium	Strong evidence exists on the benefits of specific land management activity on water quality.

Indicator G2: There will be a greater concentration of relevant agri-environment options within flood prone areas to reduce flood risk

This adaptation indicator reflects the need to improve resilience to climate change through reducing flood risk. A number of options may be used to directly reduce flood risk, including creation of buffer habitats (such as vegetated shingle, sand dune and saltmarsh), and appropriate maintenance and restoration of fen habitat that provide extra areas for water storage during periods of heavy rainfall. We may therefore expect to find a greater concentration of agri-environment options within flood prone areas.

Table 2-27 RAG assessment (indicator) – Adaptation indicator G2

Level of confidence in the indicator	Justification
High	Evidence of the benefits of nature-based solutions to flooding through the restoration of habitats is well developed.

Indicator G3: Agri-environment schemes will support the objectives of the Woodlands for Water programme

Woodlands provide a number of important ecosystem services, including improving water quality (through both trapping and retaining nutrients and sediment in polluted run-off), reducing flood risk through water storage and reducing surface run-off. There is therefore strong evidence to suggest that woodland creation in appropriate locations can achieve water management and water quality objectives, particularly those relating to the WFD (Environment Agency, 2011), and help to build resilience to climate change.

Riparian and floodplain woodland may also contribute to protecting river morphology and moderating river temperatures. Therefore, targeted woodland buffers along mid-slope or downslope field edges, or on infiltration basins, are effective for slowing down runoff and intercepting sediment and nutrients (Environment Agency, 2011). Further, wider woodland planting, particularly at the landscape scale, can help to reduce fertiliser and pesticide losses into water, as well as protecting the soil from regular disturbance and so reduce the risk of sediment delivery to watercourses. With this in mind, the Environment Agency undertook a study in 2011 to review measures available to meet WFD objectives using woodlands and produced a series of opportunity maps to aid the identification (and prioritisation) of woodland creation (Broadmeadow *et al.,* 2014).

Table 2-28 RAG assessment (indicator) – Adaptation indicator G3

Level of confidence in the indicator	Justification
High	Evidence of the ecosystem service benefits provided by woodlands are well documented and understood.

H. Storing and sequestering carbon

Indicator H1: Agri-environment schemes contribute to the storage and sequestration of carbon

Climate change mitigation is an important objective of ES. Although it is seldom (and unlikely to be) the sole driver of land management decisions, land management for climate change mitigation, through carbon sequestration, may provide multiple benefits (Natural England, 2012d). The agricultural and land management sectors have a significant influence on UK GHG emissions and carbon storage.

Targeting habitat creation to areas with high carbon storage will be locking in carbon for the long-term. Ideally this will be positioned close to habitat maintenance options to support adaptation by promoting the resilience and coherence of ecological networks, thereby improving the ability of species to move through landscapes in response to climate change.

Delivering appropriate CS options to high sequestration areas will be reducing emissions loss from these locations. For example, by positioning arable reversion or pollen and nectar mix options onto high sequestration areas you will be delivering in-combination results.

Options to maintain, restore and create semi-natural habitats and historic features achieve valuable benefits in protecting existing carbon stores and increasing the carbon content of restored and new habitats; they also contribute towards the first NAP objective, building resilience to climate change (Table 1-1). The protection and restoration of peatland soils is of benefit to the sequestration of carbon and is a priority (Natural England, 2012d). For example, where maintenance options are used to protect habitats that are already in good condition, there will be significant levels of soil carbon which the options will help to protect; this is particularly the case for peatland habitats. Therefore, we may expect agri-environment schemes to contribute to the storage and sequestration of carbon.

Table 2-29 RAG assessment (indicator) – Adaptation indicator H1

Level of confidence in the indicator	Justification
High	The evidence of the degree to which land use and land management promotes carbon storage and sequestration is well developed.

I. Targeting and applying interventions in a cost-effective and adaptive way

Indicator I1: Adaptation in the natural environment will be consistent with agricultural adaptation

A range of physical factors (including climate, site and soil), alongside interactions between them, influence the quality of land and its ability to support agriculture. For example, the combination of climate (temperature and rainfall, aspect, exposure and frost risk) and soil factors (texture, structure, depth and stoniness and chemical properties which are unable to be corrected) determines the soil wetness and 'droughtiness' (Natural England, 2012c). The Agricultural Land Classification (ALC) (see MAFF, 1988) provides a method for assessing the quality of farmland to enable informed choices to be made about its future use. The ALC categorises agricultural land into the following five categories:

- **Grade 1 (Excellent quality)** – Land with no or very minor limitations to agricultural use. A very wide range of agricultural and horticultural crops can be grown and commonly include top fruit, soft fruit, salad crops and winter harvested vegetables. Yields are high and less variable than on land of lower quality;

- **Grade 2 (Very good quality)** - Land with minor limitations which affect crop yield, cultivations or harvesting. A wide range of agricultural and horticultural crops can usually be grown but on some land of this grade there may be reduced flexibility due to difficulties with the production of the more demanding crops such as winter harvested vegetables and arable root crops. The level of yield is generally high but may be lower or more variable than Grade 1;
- **Sub-Grade 3a (Good quality)** - Land capable of consistently producing moderate to high yields of a narrow range of arable crops, especially cereals, or moderate yields of a wide range of crops including cereals, oilseed rape, potatoes sugar beet and the less demanding horticultural crops;
- **Sub-Grade 3b (Moderate quality)** - Land capable of producing moderate yields of a narrow range of crops, principally cereals and grass or lower yields of a wider range of crops or high yields of grass which can be grazed or harvested over most of the year;
- **Grade 4 (Poor quality)** - Land with severe limitations which significantly restrict the range of crops and/or level of yields. It is mainly suited to grass with occasional arable crops (e.g. cereals and forage crops) the yields of which are variable. In most climates, yields of grass may be moderate to high but there may be difficulties in utilisation. The grade also includes very droughty arable land; and
- **Grade 5 (Very poor quality)** - Land with very severe limitations which restrict use to permanent pasture or rough grazing, except for occasional pioneer forage crops.

The use of land for habitat creation (with a realistic expectation of permanence), entails an opportunity cost: that land cannot then be used for other purposes, such as agriculture, or only to a limited degree. The pressures on land use in England are the subject of much debate, with expectations that these pressures will increase over time (due to factors such as population growth and climate change). Hence, it is worthwhile considering these land use choices as part of a monitoring protocol. Determining the preferred location of habitat creation opportunities should not be constrained by consideration of alternative uses of the land but, it will be informative to understand the scale of that opportunity cost: where land use change to habitat creation takes place, what is the loss to alternative uses and, crucially, does this impact on adaptation in other sectors?

To fully understand these potential trade-offs between adaptive capacities in different sectors we would need to better understand adaptation strategies in these sectors. For example, habitat creation on lowland peatlands soils may in fact improve adaptation by arresting the process of soil erosion and hence protecting the peat soil as a productive resource for potential future use. Similarly, land that is currently productive for agriculture may become less so in future due to climate change, particularly the high percentage of productive agricultural land that is at risk from sea level rise.

For now, it is possible to simply look at the area of land used for habitat creation and measure the proportion of that land in each ALC grade. However, this would not represent a thorough understanding of the opportunity costs of land use change for habitat creation and the theory behind this proposed indicator would need development for it to be included in a monitoring programme.

Table 2-30 RAG assessment (indicator) – Adaptation indicator I1

Level of confidence in the indicator	Justification
n/a	This is a monitoring indicator rather than an indicator designed to prioritise action.

Indicator I2: Options will be implemented in a flexible way to facilitate adaptive management

Climate change is leading to increased climatic uncertainty, both between and within years, meaning that agri-environment schemes need to deliver their environmental objectives under an increasingly variable climate. Adaptation needs to be developed with less knowledge and more uncertainty than is usual when making management decisions. Accepting uncertainty and adopting approaches, such as adaptive management, is widely advocated (Natural England and RSPB, 2014). More adaptive management is a key principle of the second NAP objective (accommodating change) and affording farmers/land managers greater flexibility in implementing options will contribute towards this principle.

Flexibility is essential when responding to climate change. Ensuring that agri-environment schemes promotes flexibility both in terms of the capacity of agreement holders to respond to increased climate uncertainty, and in the promotion of a range of adaptive responses should underpin the current and future design and delivery of agri-environment schemes.

Flexibility at the national-scale is not best assessed using uptake patterns, particularly against the objective of creating a baseline from which to compare future change. It is suggested that the ability of schemes to deliver flexibility is best assessed (and monitored) at local scales (see Section 5.1.1) with a supporting review of scheme structure and function when new agri-environment schemes are being designed to ensure that flexibility is built into the scheme.

Table 2-31 RAG assessment (indicator) – Adaptation indicator I2

Level of confidence in the indicator	Justification
High	Flexibility in is an essential element when responding to climate change. Ensuring that agri-environment schemes promotes flexibility both in terms of the capacity of agreement holders to respond to increased climate uncertainty, and also in the promotion of a range of adaptive responses should underpin the current and future design and delivery of agri-environment schemes.

Indicator I3: Agri-environment options will accommodate change where appropriate

The impacts of climate change are already leading to observed changes to the natural environment (Morecroft and Speakman, 2015) and farming systems (LWEC, 2016) and these changes are likely to increase over time (Defra, 2012; Adaptation Sub-Committee, 2013; Committee on Climate Change, 2016b). The need to accommodate change is well documented (Defra, 2008; HM Government, 2011). Where possible, agreements (including objective setting, option deployment and prescription setting) should accommodate change where change is inevitable.

Table 2-32 RAG assessment (indicator) – Adaptation indicator I3

Level of confidence in the indicator	Justification
High	Climate change will lead to changes to both the natural environment and agriculture. Ensuring that agri-environment schemes enables change where it is beneficial is essential for the adaptation of agriculture and the natural environment.

3. Developing the national-scale element of the monitoring framework

The desired outcomes set out in the previous section can be evaluated at a national and local scale to different degrees using different approaches. The following section outlines the approach to monitoring these outcomes nationally. The monitoring framework uses a Geographic Information System (GIS) -based approach using the spatial pattern of option uptake to compare with underlying spatial data.

The two ways of working outcomes (i.e. the promotion of flexibility and adaptive management, indicators I2 and I3 respectively) need to be monitored in a different manner using an assessment of the scheme structure and auditing (this is described in more detail in Section 5).

3.1. Methods

3.1.1.1. Data

A number of spatial datasets were reviewed in order to facilitate the development of the national-scale element of the monitoring framework and, ultimately, the baseline assessment from which future change is able to be compared. Table 3-1 below provides a summary of the datasets that were consulted, whilst Table A-1 (in Appendix A) provides a more comprehensive overview of each dataset.

Table 3-1 A summary of datasets consulted in development of the baseline

Dataset	Description	No.
Environmental Stewardship options	This data depicts ES options as points. There are field centroids (ELS options) and holding centroids (rotational ELS and HLS options). A range of information is provided including the specific options that are included in each agreement and the area (in hectares) or length (in metres) over which the option is applied. In total, there are approximately 1.3 million option points covering England. The records were extracted on 1st January, 2015.	1
England Woodland Grant Scheme	The EWGS offers six grants for the creation and stewardship of woodlands and is operated by the Forestry Commission (see Table 1-3). The component grant types of EWGS (including maintenance, restoration and creation of woodlands) have their own objectives. Some grants are focused regionally to meet the priorities of Regional Forestry Framework action plans, and the objectives are specified more closely to suit.	2
Priority Habitats	The UK Biodiversity Action Plan (BAP) priority habitats cover a range of semi-natural habitat types. They have been identified as being the most threatened and require conservation action under the UK BAP. The UK BAP has now been superseded by devolved biodiversity plans but the priority habitat framework remains.	3
Utilisable Agricultural Area	The Utilisable Agricultural Area (UAA) is a dataset that delineates land areas that are considered to be able to support agriculture (i.e. not built up or urban areas).	4
NBCCVA most vulnerable – all habitats	Outputs from the National Biodiversity Climate Change Vulnerability Assessment (NBCCVA) (see Natural England, 2014). A number of metrics were used to determine overall vulnerability to climate change. Outputs include four metrics - sensitivity to climate change, habitat fragmentation, topographic heterogeneity and management and condition - to determine overall vulnerability for all priority habitats at a 200m x 200m grid resolution. Where two or more habitats are found in a grid square the scores for the most vulnerable habitat overall is presented.	5
NBCCVA most vulnerable – individual habitat assessments	As above, but this model output has been derived using the four metrics, notably: sensitivity to climate change, habitat fragmentation, topographic heterogeneity and management and condition, to assess the vulnerability of priority habitats individually. It depicts overall vulnerability for each priority habitat at a 200m x 200m grid resolution.	6
NBCCVA fragmentation areas	These layers depict areas where individual habitats are highly fragmented. These fragmented habitat patches may provide a potential 'area of search' for habitat creation opportunities that enhance the habitat network. Two categories of 'fragmentation area' (at 1 km proximity) are provided for 25 priority habitat types with the 'top 20%' areas representing fragmentation areas that have been identified where fragmented habitat patches occur in clusters that are in close proximity to each other and therefore those providing the greatest potential to enhance fragmented habitat networks. Another set of fragmentation areas depicts the remaining 80% of fragmented habitat patches that may	7

Dataset	Description	No.
	be more isolated from each other but that may also provide opportunities for reducing fragmentation and increasing habitat patch size.	
Flood Risk Zones	The Flood Risk Zones (more commonly referred to as ‘Flood Zones 2 and 3’) shows the areas across England and Wales that could be affected by flooding from rivers or the sea. It also shows flood defences and, for major defences, areas that benefit from them. It does not show the effects of climate change. It also does not show where flooding from other sources such as groundwater or runoff from rainfall may or may not occur.	8
Soils	Natmap vector. A broad resolution (1:250,000) scale map of England and Wales, showing the locations of 297 distinct soil associations. Within each of the soil associations are multiple soil series.	9
Nitrate Vulnerable Zones	Areas of England and Wales that are designated as Nitrate Vulnerable Zones (NVZ). NVZs are a form of conservation designation afforded by the Environment Agency for areas of land that drain nitrate into polluted waters, or waters which could become polluted by nitrates.	10
Species refugia	These maps, developed by the University of Exeter as part of a joint project with Natural England (Suggitt *et al.*, 2014), show the relative potential for each part of England, at 10km resolution, to provide refugia from climate change (0=low refugium potential; 1= high). They were created by mapping the locations of environmental characteristics that were shown to be significant in an analysis of local survival or disappearance of over 1,000 species that retracted their ranges in England over the past 40 years. The maps represent refugia that are likely to arise from topographic, microclimatic and geological diversity, and protection from intensive agriculture.	11
Agricultural Land Classification (ALC)	Agricultural Land Classification (ALC) Grade for post-1988 ALC surveys. Includes grades 1, 2, 3a, 3b, 4 and 5. For more information see http://publications.naturalengland.org.uk/file/97005. Not updated.	12
Woodland habitat networks	Priority areas of woodland that have been buffered by various distances (typically 400m and 600m). These areas represent ideal habitat corridors to enable species’ movement through the landscape. These layers are the output of a project by the Forest Research (see here: http://www.forestry.gov.uk/fr/habitatnetworks)	13
Priority areas for conserving biodiversity under current and projected future climatic conditions	Maps at the 10km resolution that depict the priority of areas (0=low conservation priority, 1=high conservation priority) for conserving biodiversity under current and future climatic conditions. They are based on analysis using the Zonation systematic conservation planning software to analyse modelled current and future suitable climate space for over 3000 species.	14
National Character Areas	NCAs divide England into 159 distinct natural areas. Each is defined by a unique combination of landscape, biodiversity, geodiversity, history, and cultural and economic activity. Their boundaries follow natural lines in the landscape rather than administrative boundaries. Often used as a reporting framework.	15
Possible species turnover	Maps at 10 km resolution showing possible future rates of turnover of species, based on comparing maps of modelled current and future suitable climate created for over 3000 species in the project by Pearce-Higgins *et al.*, (2015a). The calculations of species turnover, by taxa, use three commonly used, but different, measures (Whittaker, Sorensen and Simpson). The maps give a simple overall estimate of change in each square; they do not show relative proportions of species arriving, leaving or staying, nor are potential new arrivals to England taken into consideration. The impacts of invasive species are not considered.	16
Water Quality Priority Areas	A series of zones that delineate priority areas for improving water quality. Scored based on seven different water quality issues, including groundwaters and rivers at risk from nitrate pollution, groundwaters and rivers at risk of pesticide pollution, faecal indicators, sediment risks and phosphate risks.	17
Keeping River Cool	A series of maps that delineate riparian shading from trees and vegetation. Areas of riparian shade provide refugial habitat for salmon and brown trout populations that are expected to be at risk from the effects of climate change. Project developed by the Environment Agency.	18
Woodlands for Water	Woodland areas providing water quality benefits in the context of the Water Framework Directive (WFD). The project was undertaken by Forest Research and employed spatial mapping to target areas that may contribute most to maximising water and other benefits.	19
SSSI	Sites of Special Scientific Interest. A protected conservation designation in the UK. SSSIs are the basic building blocks of site-based nature conservation legislation; these sites often contain our most important, and sometimes vulnerable, species and habitats.	20

Dataset	Description	No.
Habitat potential areas	A series of maps that delineate areas of habitat potential for a range of priority habitats, including blanket bog, coastal saltmarsh, coastal sand dune, coastal vegetated shingle, fen, lowland raised bog and reedbed. For each habitat potential map, a range of factors (e.g. soils, hydrology, slope, location etc.) have been considered to help identify those areas best able to support each habitat type. These maps were developed as a baseline from which to measure progress against the Bio2020 outcome 1D that aims to restore at least 15% of degraded ecosystems (see Defra, 2011).	21
Anonymised CLAD (Rural Land Register) parcels	Land parcels boundaries from the Rural Land Register (with owners removed), depicting all land parcels that have been signed up to receive funding through agri-environment schemes. Useful for determining the total area of land applicable to receive funding.	22

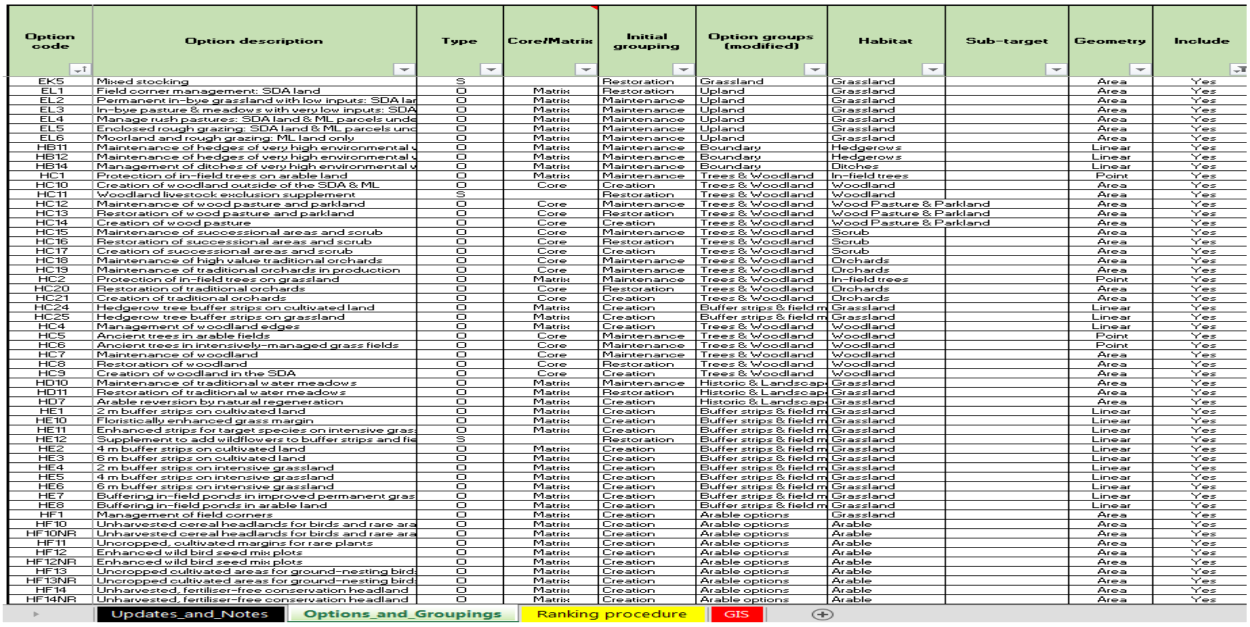
Note: The ‘No.’ column refers to the identification number assigned to each dataset as referenced in Table A-1 (Appendix A).

3.1.1.2. Grouping agri-environment options

In conjunction with the Steering Group, an interactive MS Excel tool was developed that allowed users to filter the 467 unique ES options depending on a range of variables, notably:

- **Type** – e.g. an option or a supplement**;**
- **Core/Matrix** – e.g. options that support core habitat creation, maintenance or restoration or matrix features which improve permeability through the landscape (i.e. buffer strips, hedgerow restoration etc.);
- **Initial grouping** – e.g. maintenance, restoration or creation;
- **Option groups** – a secondary classification that groups options into a range of broad types based upon the habitat or feature (e.g. historic and landscape, buffer strips and field margins, wetlands etc.);
- **Habitat** – the type(s) of habitat(s) over which the option(s) may be applied;
- **Sub-target** – e.g. if the option(s) also has a secondary benefit, for example reducing flood risk, improving water quality or for birds (or a combination of any of these);
- **Geometry** – e.g. options that are able to be applied over land areas or those only over linear features, such as hedgerows; and
- **Include** – e.g. a simple Yes/No field to distinguish between options that were/were not considered in the analyses. Those options supporting capital works, such as maintenance of traditional farm buildings or stone wall restoration, were not included in the study as these options are unlikely to support adaptation of the natural environment to climate change.

Figure 3-1 provides a screenshot of the tool that was developed. Each of the options is listed in the left most column alongside a description before the filtering criteria (described above) are each listed in turn. The development of this tool is a key output of the project and, in combination with the spatial data identified above (Section 3.1), facilitates the development of a set of adaptation indicators.



Option code	Option description	Type	Core/Matrix	Initial grouping	Option groups (modified)	Habitat	Sub-target	Geometry	Include
EK5	Mixed stocking	S		Restoration	Grassland	Grassland		Area	Yes
EL1	Field corner management: SDA land	O	Matrix	Restoration	Upland	Grassland		Area	Yes
EL2	Permanent in-bye grassland with low inputs: SDA lar	O	Matrix	Maintenance	Upland	Grassland		Area	Yes
EL3	In-bye pasture & meadows with very low inputs: SDA	O	Matrix	Maintenance	Upland	Grassland		Area	Yes
EL4	Manage rush pastures: SDA land & ML parcels unde	O	Matrix	Maintenance	Upland	Grassland		Area	Yes
EL5	Enclosed rough grazing: SDA land & ML parcels unc	O	Matrix	Maintenance	Upland	Grassland		Area	Yes
EL6	Moorland and rough grazing: ML land only	O	Matrix	Maintenance	Upland	Grassland		Area	Yes
HB11	Maintenance of hedges of very high environmental v	O	Matrix	Maintenance	Boundary	Hedgerows		Linear	Yes
HB12	Maintenance of hedges of very high environmental v	O	Matrix	Maintenance	Boundary	Hedgerows		Linear	Yes
HB14	Management of ditches of very high environmental v	O	Matrix	Maintenance	Boundary	Ditches		Linear	Yes
HC1	Protection of in-field trees on arable land	O	Matrix	Maintenance	Trees & Woodland	In-field trees		Point	Yes
HC10	Creation of woodland outside of the SDA & ML	O	Core	Creation	Trees & Woodland	Woodland		Area	Yes
HC11	Woodland livestock exclusion supplement	S		Restoration	Trees & Woodland	Woodland		Area	Yes
HC12	Maintenance of wood pasture and parkland	O	Core	Maintenance	Trees & Woodland	Wood Pasture & Parkland		Area	Yes
HC13	Restoration of wood pasture and parkland	O	Core	Restoration	Trees & Woodland	Wood Pasture & Parkland		Area	Yes
HC14	Creation of wood pasture	O	Core	Creation	Trees & Woodland	Wood Pasture & Parkland		Area	Yes
HC15	Maintenance of successional areas and scrub	O	Core	Maintenance	Trees & Woodland	Scrub		Area	Yes
HC16	Restoration of successional areas and scrub	O	Core	Restoration	Trees & Woodland	Scrub		Area	Yes
HC17	Creation of successional areas and scrub	O	Core	Creation	Trees & Woodland	Scrub		Area	Yes
HC18	Maintenance of high value traditional orchards	O	Core	Maintenance	Trees & Woodland	Orchards		Area	Yes
HC19	Maintenance of traditional orchards in production	O	Core	Maintenance	Trees & Woodland	Orchards		Area	Yes
HC2	Protection of in-field trees on grassland	O	Matrix	Maintenance	Trees & Woodland	In-field trees		Point	Yes
HC20	Restoration of traditional orchards	O	Core	Restoration	Trees & Woodland	Orchards		Area	Yes
HC21	Creation of traditional orchards	O	Core	Creation	Trees & Woodland	Orchards		Area	Yes
HC24	Hedgerow tree buffer strips on cultivated land	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HC25	Hedgerow tree buffer strips on grassland	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HC4	Management of woodland edges	O	Matrix	Creation	Trees & Woodland	Woodland		Linear	Yes
HC5	Ancient trees in arable fields	O	Core	Maintenance	Trees & Woodland	Woodland		Point	Yes
HC6	Ancient trees in intensively-managed grass fields	O	Core	Maintenance	Trees & Woodland	Woodland		Point	Yes
HC7	Maintenance of woodland	O	Core	Maintenance	Trees & Woodland	Woodland		Area	Yes
HC8	Restoration of woodland	O	Core	Restoration	Trees & Woodland	Woodland		Area	Yes
HC9	Creation of woodland in the SDA	O	Core	Creation	Trees & Woodland	Woodland		Area	Yes
HD10	Maintenance of traditional water meadows	O	Matrix	Maintenance	Historic & Landscap	Grassland		Area	Yes
HD11	Restoration of traditional water meadows	O	Matrix	Restoration	Historic & Landscap	Grassland		Area	Yes
HD7	Arable reversion by natural regeneration	O	Matrix	Creation	Historic & Landscap	Grassland		Area	Yes
HE1	2 m buffer strips on cultivated land	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE10	Floristically enhanced grass margin	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE11	Enhanced strips for target species on intensive gras	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE12	Supplement to add wildflowers to buffer strips and fie	S		Restoration	Buffer strips & field m	Grassland		Linear	Yes
HE2	4 m buffer strips on cultivated land	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE3	6 m buffer strips on cultivated land	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE4	2 m buffer strips on intensive grassland	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE5	4 m buffer strips on intensive grassland	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE6	6 m buffer strips on intensive grassland	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE7	Buffering in-field ponds in improved permanent gras	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HE8	Buffering in-field ponds in arable land	O	Matrix	Creation	Buffer strips & field m	Grassland		Linear	Yes
HF1	Management of field corners	O	Matrix	Creation	Arable options	Grassland		Area	Yes
HF10	Unharvested cereal headlands for birds and rare ara	O	Matrix	Creation	Arable options	Arable		Area	Yes
HF10NR	Unharvested cereal headlands for birds and rare ara	O	Matrix	Creation	Arable options	Arable		Area	Yes
HF11	Uncropped, cultivated margins for rare plants	O	Matrix	Creation	Arable options	Arable		Area	Yes
HF12	Enhanced wild bird seed mix plots	O	Matrix	Creation	Arable options	Arable		Area	Yes
HF12NR	Enhanced wild bird seed mix plots	O	Matrix	Creation	Arable options	Arable		Area	Yes
HF13	Uncropped cultivated areas for ground-nesting bird	O	Matrix	Creation	Arable options	Arable		Area	Yes
HF13NR	Uncropped cultivated areas for ground-nesting bird	O	Matrix	Creation	Arable options	Arable		Area	Yes
HF14	Unharvested, fertiliser-free conservation headland	O	Matrix	Creation	Arable options	Arable		Area	Yes
HF14NR	Unharvested, fertiliser-free conservation headland	O	Matrix	Creation	Arable options	Arable		Area	Yes

Figure 3-1 Screenshot showing the interactive Excel tool

For future monitoring, the new CS options will need to be classified using the same approach.

3.1.1.3. Detailed assessment of the adaptation indicators

This section provides a detailed assessment of each of the adaptation indicators outlined in the previous section and the resulting questions that may be used to test (and monitor) them at the national-scale. For each, a rationale and assessment is provided in the context of data availability and suitability (Section 3.1), and a monitoring question subsequently identified. Filtering that was applied using the MS Excel tool (see Section 3.1.1.2) is also provided. A Red-Amber-Green (RAG) approach, similar to that used earlier (Section 2.1), has been applied to describe (and summarise) our confidence in the data that are available/most suitable to test each indicator, where:

High	Good quality data is available (and suitable) to test the adaptation indicator;
Medium	Some good quality data is available (and may be suitable) to test the adaptation indicator; and
Low	Data is not available and/or not suitable to test the adaptation indicator

Ultimately, the indicators in this list, or a subset of them, would be used to develop the national-scale baseline assessment to which future change would be able to be compared; a summary of the final list of adaptation indicators selected is provided in Section 3.1.1.4.

A. Protecting the most important and vulnerable sites

Indicator A1: Maintenance and restoration options will be coincident with priority habitats

Monitoring question (national-scale): What is the proportion of priority habitat covered by appropriate maintenance and restoration options?

Data

UK BAP priority habitats and agri-environment scheme (ES) data are required, both of which are widely available and regularly updated. Only those maintenance and restoration options that focus on core habitat should be considered. In total, there are 34 relevant options (see Appendix D) identified using the Excel tool (see Section 3.1.1.2), including Woodland Management (WMG) and Woodland Restoration Grants. Note: fragmented heath and grass moorland were included in the identified options.

Table 3-2 Excel tool filtering – Adaptation indicator A1

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Maintenance, Restoration
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-3 RAG assessment (data) – Adaptation indicator A1

Level of confidence in the data	Justification
Medium	Accurate spatial data exists on the location of priority habitats. Available agri-environment scheme data uses parcel centroids, full georeferenced data would improve the analysis.

Indicator A2: The condition of priority habitat under agri-environment schemes will be higher than that of priority habitat not under agri-environment schemes

Monitoring question (national-scale): What is the proportion and total area of maintenance and restoration options within, and outside of, priority habitats?

Data

Data on the location (and condition) of UK BAP priority habitats and agri-environment schemes are required. The former is widely available and regularly updated. However, condition assessments are locally produced and the results of which nationally reported. Moreover, reporting the condition of habitats outside of priority habitats is problematic as this data is seldom available outside of comprehensive monitoring frameworks covering these areas. Therefore, scale is an important consideration here and it is likely that habitat condition is best reported (and more easily analysed) at the local-, rather than national-, scale.

Table 3-4 Excel tool filtering – Adaptation indicator A2

Filter	Selection
Type	Option
Core/Matrix	-
Initial grouping	Maintenance
Option groups	-
Habitat	Exclude Arable, Open water
Sub-target	-
Geometry	Area
Include	Yes

Table 3-5 RAG assessment (data) – Adaptation indicator A2

Level of confidence in the data	Justification
Low	Limited availability of data. Priority habitat outside agri-environment schemes is poorly monitored and the condition of priority habitat under agri-environment schemes is not available spatially.

Indicator A3: Agri-environment schemes will support SSSIs

Monitoring question (national-scale): What is the proportion and total area of SSSIs covered by maintenance and restoration options?

Data

A dataset of SSSIs is available for England and is updated on a frequent (quarterly) basis. Only core options that focus on the maintenance and restoration of habitats should be considered. In total, there are 34 relevant options identified (see Appendix D), including Woodland Management and Woodland Regeneration Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-6 Excel tool filtering – Adaptation indicator A3

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Maintenance, Restoration
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-7 RAG assessment (data) – Adaptation indicator A3

Level of confidence in the data	Justification
Medium	SSSI data exists in accurate GIS form. Available agri-environment schemes data uses parcel centroids, full georeferenced data would likely improve the analysis.

Indicator A4: Restoration and maintenance options will support highly sensitive habitats

In 2014, Natural England and the RSPB developed a comprehensive assessment of 34 priority habitats and their sensitivity to climate change (ranked high to low). Highly sensitivity habitats are those whose existence is dependent on specific climatic, hydrological or coastal conditions, which projections indicate will change with climate change (e.g. coastal saltmarsh, lowland fen etc.). The low sensitivity habitats are those which are determined by other factors, such as grazing or geology, or more generalist species, and where climate plays only a minor role (e.g. deciduous woodland, lowland calcareous grasslands etc.). The NBCCVM also used habitat sensitivity as a metric to derive overall vulnerability for a range of priority habitats (see Natural England, 2014).

Due to the limited range of sensitivities used in both cases (i.e. a simple high/medium/low scale was adopted) the project Steering Group developed a more detailed sensitivity classification based on a quantitative scale (where 1=high sensitivity, 5=low sensitivity). Table C-1 (Appendix C) provides an overview of the three sensitivity classifications described for different priority habitat types. These studies of sensitivity are important to assist prioritisation and planning for biodiversity adaptation, including the planning of ecological networks, landscape scale habitat creation and management planning.

Monitoring question (national-scale): Of habitats with High, Medium or Low (and 1-5) sensitivities, what is the proportion under appropriate restoration and maintenance options?

Data

Priority habitat data is widely available and updated on a regular basis. The sensitivity classifications (see Table C-1) are able widely available and easily linked to the priority habitat data in a GIS. Only restoration and maintenance options that focus on core habitat should be considered (see Appendix D). In total, there are 34 relevant core creation options identified, including Woodland Management and Woodland Regeneration Grants, using the Excel tool (see Section 3.1.1.2).

The sensitivity of habitats is likely to range from high to low. Expert judgement has been used to determine the 1-3 or 1-5 categories which are arbitrary. It is likely that in practice there will be overlap and sensitivity will be a gradient influenced by the species composition and abundance of habitats.

Table 3-8 Excel tool filtering – Adaptation indicator A4

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Maintenance, Restoration
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-9 RAG assessment (data) – Adaptation indicator A4

Level of confidence in the data	Justification
Medium	The sensitivity of habitats is likely to range from high to low. Expert judgement has been used to determine the 1-5 categories which are arbitrary. It is likely that in practice there will be overlap and sensitivity will be a gradient influenced by the species' composition and abundance of habitats.

Indicator A5: Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)

Monitoring question (national-scale): What is the area of creation option uptake by each sensitivity class?

Data

Priority habitat data is widely available and updated on a regular basis. The sensitivity classifications (see Table C-1) are able widely available and easily linked to the priority habitat data in a Geographic Information System (GIS). Only creation options that focus on core habitat should be considered. In total, there are 19 relevant core creation options identified (see Appendix D), including Woodland Creation Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-10 Excel tool filtering - Adaptation indicator A5

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-11 RAG assessment (data) – Adaptation indicator A5

Level of confidence in the data	Justification
Medium	The resolution of the national agri-environment scheme data is likely to be insufficient to determine the target habitat for creation.

Indicator A6: Agri-environment management will create shade for rivers where this is a priority for the freshwater habitat

Monitoring question (national-scale): What is the proportion and total area of appropriate options supporting objectives of Keeping Rivers Cool programme?

Data

The Keeping Rivers Cool data is available from the Environment Agency. It uses high resolution topographic mapping (LiDAR) to derive areas of tall vegetation and to identify gaps that may represent opportunities for planting trees and other tall vegetation. As such, the data is limited to riparian zones and there is often limited overlap between these (sometimes narrow) areas and the surrounding agricultural landscape (these narrow zones are intended to be used to inform local-scale planning). Moreover, given the (relatively coarse) spatial scale of the agri-environment options data that is available (land parcel/agreement centroids – see Table 3-1) there is unlikely to be crossover between these two datasets. It is therefore likely that significant underreporting of any coincidences would occur and this indicator is best monitored at the local-scale.

Only options that focus on the restoration and creation of woodland should be considered. In total, there 22 relevant options were selected (see Appendix D), including Woodland Management and Woodland Regeneration Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-12 Excel tool filtering - Adaptation indicator A6

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation, Maintenance, Restoration
Option groups	Trees & Woodland

Filter	Selection
Habitat	-
Sub-target	-
Geometry	Area, Linear, Point
Include	Yes

Table 3-13 RAG assessment (data) – Adaptation indicator A6

Level of confidence in the data	Justification
Low	Data is available and quality checked. National data is available as point data so the resolution is unlikely to be sufficient to determine the appropriateness of action. Better suited to local scale analyses and application(s).

B. Reducing fragmentation and enhancing ecological networks

Indicator B1: Creation options will reduce fragmentation

To ensure that action is prioritised in locations that reduce fragmentation the NBCCVA identifies sites that represent the greatest opportunity for reducing fragmentation and these have been supplied. It is further possible to buffer these priority areas to enable an assessment of habitat creation within close proximity of these sites.

Monitoring question (national-scale): What is the proportion and total area of appropriate creation options in each fragmentation area?

Data

Layers depicting areas of habitat that are highly fragmented but may provide potential 'areas of search' for habitat creation, restoration or maintenance are available as outputs from the NBCCVA data; two sets of 'fragmentation areas' (at 1 km proximity to these highly fragmented sites) are provided for 25 priority habitat types; these sites are further classified into those sites representing the greatest opportunities to enhance fragmented habitat networks using quantile breaks (i.e. the 'top 20%' of the most highly fragmented sites). Another set of 'fragmentation areas' are also provided that represent all other fragmented habitat patches (i.e. the remaining 80% of highly fragmented sites). Only creation options that focus on core habitat should be considered (see Appendix D). In total, there are 13 relevant core creation options identified using the Excel tool (see Section 3.1.1.2).

Table 3-14 Excel tool filtering – Adaptation indicator B1

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-15 RAG assessment (data) – Adaptation indicator B1

Level of confidence in the data	Justification
High	The NBCCVM uses a robust methodology to identify highly fragmented areas. Agri-environment options supporting core habitat creation are easily identifiable.

Indicator B2: Restoration options will support the reduction of fragmentation

This adaptation indicator is almost identical to indicator B1 except that it focusses on restoration and maintenance options, rather than creation options.

Monitoring question (national-scale): What is the proportion and total area of appropriate restoration options in each fragmentation area?

Data

Layers depicting areas of habitat that are highly fragmented but may provide potential 'areas of search' for habitat creation, restoration or maintenance are available as outputs from the NBCCVA data; two sets of 'fragmentation areas' (at 1 km proximity to these sites) are provided for 25 priority habitat types; these sites are further classified into those sites representing the greatest opportunities to enhance fragmented habitat networks using quantile breaks (i.e. the 'top 20%' of the most highly fragmented sites). Another set of 'fragmentation areas' are also provided that represent all other fragmented habitat patches (i.e. the remaining 80% of highly fragmented sites). Only restoration options that focus on core habitat should be considered see Appendix D). In in total, there are seven relevant restoration options identified using the Excel tool (see Section 3.1.1.2). The amount and quality of restoration is difficult to ascertain and, more so, how this may lead to a change in fragmentation; restoration of habitats in the context of habitat fragmentation may be better assessed at the local-scale.

Table 3-16 Excel tool filtering – Adaptation indicator B2

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Restoration
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Upland, Wetland
Habitat	-
Sub-target	Exclude all sub-targets
Geometry	Area
Include	Yes

Table 3-17 RAG assessment (data) – Adaptation indicator B2

Level of confidence in the data	Justification
Medium	The NBCCVA uses a robust methodology to identify highly fragmented areas. Agri-environment options supporting core habitat creation are easily identifiable. However much depends on how the habitat to be restored is classified as to whether its restoration will lead to a change in the fragmentation metric.

Indicator B3: Woodland creation options will help to reduce woodland fragmentation

This is similar to B1 but it focuses on woodland creation (as opposed to the creation of all habitat types). It uses grids of woodland habitat fragmentation at 200 m x 200 m resolution, as output from the NBCCVA, to assess the interrelationship between the creation of woodland habitat and woodland fragmentation. These fragmentation grids may be further prioritised by those areas representing the greatest opportunities for reducing woodland fragmentation by sorting the fragmentation scores in descending order and splitting the range into five categories (i.e. the 'top 20% of the most highly fragmented woodland sites and so on).

Monitoring question (national-scale): What is the proportion and total area of appropriate woodland creation options within each fragmentation band (just for woodland fragmentation)?

Data

Grids at 200 m x 200 m resolution depicting sites of the most fragmented woodland habitats are available from the NBCCVA; sorting these sites by their relative fragmentation scores (and splitting the data range into five categories) provides a series of fragmentation bands (most fragmented to least fragmented) which may facilitate an assessment of woodland fragmentation. Only options that focus on the creation of core woodland habitats should be considered. In total, six relevant core woodland creation options (see Appendix D) were identified, including Woodland Creation Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-18 Excel tool filtering – Adaptation indicator B3

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation
Option groups	Trees & Woodland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-19 RAG assessment (data) – Adaptation indicator B3

Level of confidence in the data	Justification
High	The underlying spatial data of woodland networks and the spatial pattern of woodland options is available. This indicator is covered in scope by indicators B7 and F1 and therefore is not required to be taken forward into the national-scale baseline assessment.

Indicator B4: Woodland restoration and maintenance options will support the reduction of woodland fragmentation

This is a similar indicator to B3 but it instead focuses on restoration and maintenance options rather than creation options (it is the therefore the woodland equivalent of indicator B2).

Monitoring question (national-scale): What is the proportion and total area of appropriate woodland restoration and maintenance options in each fragmentation band (just for woodland fragmentation)?

Data

Grids, at 200 m x 200 m resolution, depicting sites of the most fragmented woodland habitats are available from the NBCCVA; sorting these sites by their relative fragmentation scores (and splitting the data range into five categories) provides a series of fragmentation bands (most fragmented to least fragmented) which may facilitate an assessment of woodland fragmentation. Only options that focus on the maintenance and restoration of core woodland habitat should be considered. In total, there are 14 relevant options (see Appendix D) identified, including Woodland Maintenance and Woodland Regeneration Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-20 Excel tool filtering – Adaptation indicator B4

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Maintenance, Restoration
Option groups	Trees & Woodland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-21 RAG assessment (data) – Adaptation indicator B4

Level of confidence in the data	Justification
High	The underlying spatial data of woodland networks and the spatial pattern of woodland options is available. Habitat under restoration or maintenance will be recorded as woodland so the underpinning data is robust.

Indicator B5: Matrix options to restore or create features should be focused in areas of high fragmentation

Monitoring question (national-scale): What is the proportion and total area of appropriate creation and restoration matrix options in each fragmentation buffer?

Data

Layers depicting sites that are highly fragmented but may provide potential ‘area of search’ for habitat creation, restoration or maintenance are available as outputs from the NBCCVA data; two sets of ‘fragmentation areas’ (at 1km proximity to these highly fragmented sites) are provided for 25 priority habitat types; these sites are further classified into those sites representing the greatest opportunities to enhance fragmented habitat networks using quantile breaks (i.e. the ‘top 20%’ of the most highly fragmented sites). Another set of ‘fragmentation areas’ are also provided that represent all other fragmented habitat patches (i.e. the remaining 80% of highly fragmented sites). Only restoration and creation options that focus on supporting matrix features are relevant (see Appendix D). In total, there are 143 relevant options that focus on the creation and maintenance of matrix features identified using the Excel tool (see Section 3.1.1.2).

Table 3-22 Excel tool filtering – Adaptation indicator B5

Filter	Selection
Type	Option
Core/Matrix	Matrix
Initial grouping	Creation, Restoration
Option groups	Arable options, Boundary, Buffer strips & field margins, Encourage a range of crops, Grassland, Upland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-23 RAG assessment (data) – Adaptation indicator B5

Level of confidence in the data	Justification
Medium	Whilst the NBCCVM uses a robust methodology to identify highly fragmented areas, modelling the complex interactivity across habitat types, and at the landscape scale, is considerably more involved. Scale is therefore an important consideration.

Indicator B6: Creation options will enhance ecological networks

Monitoring question (national-scale): What is the proportion and total area of core creation options within 1km of priority habitats?

For broad national analysis with the data available, it is not possible to evaluate specifically how agri-environment scheme management is located in relation to likely functional networks for different species. A more general rule of thumb was therefore needed; evidence suggests 1 km from existing habitat is a reasonable value to use (Knight *et al.,* 2014; Skirvin *et al.,* 2014; Woodcock *et al*., 2015).

Data

UK BAP priority habitats and agri-environment scheme (e.g. ES) data are required, both of which are widely available and regularly updated. Only creation options that focus on core habitat creation should be considered. In total, there are 13 relevant options (see Appendix D) selected using the Excel tool (see Section 3.1.1.2).

Table 3-24 Excel tool filtering – Adaptation indicator B6

Filter	Selection
Type	Option
Core/Matrix	Core

Filter	Selection
Initial grouping	Creation
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-25 RAG assessment (data) – Adaptation indicator B6

Level of confidence in the data	Justification
Low	This indicator is covered by indicator F1.

Indicator B7: Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species

A series of maps have been developed by Forest Research to estimate where functional networks for woodland species exist between patches of woodland, and where patches are functionally isolated from each other; the aim being to prioritise areas for woodland creation that will reduce woodland fragmentation and so facilitate species movement through the landscape. To improve the functional connectivity of the landscape, we would expect options that support the creation of woodland habitats to occur close to (within 1 km) of woodland habitat networks.

Monitoring question (national-scale): What is the proportion of appropriate woodland creation options that fall within 1 km of woodland habitat networks?

Data

Woodland habitat networks are available from the Forestry Commission, and have been developed by buffering (by 1 km) priority areas of woodland. These areas represent ideal habitat corridors to enable species' movement through the landscape. These layers are the output of a project by Forest Research (see Forest Research, 2016). Only options that focus on the creation of core woodland habitats should be considered. In total, there are six relevant core woodland creation options (see Appendix D) identified, including Woodland Creation Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-26 Excel tool filtering – Adaptation indicator B7

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation
Option groups	Trees & Woodland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-27 RAG assessment (data) – Adaptation indicator B7

Level of confidence in the data	Justification
High	All data are widely available and quality checked.

C. Protecting refugia

Indicator C1: Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia

Monitoring question (national-scale): What is the area of appropriate creation, maintenance or restoration options in areas of high and low refugia?

Data

A number of maps depicting refugium potential scores (where, 0=low refugium potential, 1=high refugium potential) for England at 10 km resolution are available (see Suggitt *et al.,* 2014). These maps were created using relationships between persistence and other variables. They represent potential refugial areas that arise from microclimatic and geological diversity, and protection from intensive agriculture. The maps are useful in understanding broader scale changes and/or trends but it is likely that refugium potential is likely to be very location-specific (i.e. a small habitat patch on a north-facing slope or at the top of a mountain) and therefore dependent upon scale. Only options that have a focus on core creation, restoration and maintenance of habitats should be considered (see Appendix D). In total, there are 53 options, including Woodland Management and Woodland Regeneration Grants, identified using the Excel tool (see Section 3.1.1.2).

Table 3-28 Excel tool filtering – Adaptation indicator C1

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation, Maintenance, Restoration
Option groups	-
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-29 RAG assessment (data) – Adaptation indicator C1

Level of confidence in the data	Justification
Medium	10 km x 10 km maps are useful in understanding broader-scale changes in refugium potential but refugia is likely to be location-specific and small microclimatic impacts will be as important at the finer scale. Scale is therefore an issue.

D. Planning for potential changes in ranges and assemblages of species

Indicator D1: Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions

Monitoring question (national-scale): What is the total area of appropriate options in relation to the priority areas of future ranges of taxa?

Data

Maps at 10 km x 10 km resolution that depict priority areas (0=low conservation priority, 1=high conservation priority) for current and future distributions of a number of species under a low climate scenario are available. Only options that focus on the maintenance, restoration or creation of habitats should be considered. In total, there are 53 relevant options (see Appendix D) identified, including Woodland Creation, Woodland Maintenance and Woodland Regeneration Grants, using the Excel tool (see Section 3.1.1.2). The relatively low spatial resolution of the datasets limits their application to sub national-scale studies; therefore, this is best considered at the local-scale. However, there may be merit in exploring the coincidence of these areas with existing schemes to help build the evidence base.

Table 3-30 Excel tool filtering – Adaptation indicator D1

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation, Maintenance, Restoration
Option groups	-
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-31 RAG assessment (data) – Adaptation indicator D1

Level of confidence in the data	Justification
Low	Maps at 10 km x 10 km resolution that depict priority areas (0=low conservation priority, 1=high conservation priority) for current and future distributions of a number of species under a low climate scenario are available. The relatively low spatial resolution of the datasets limits their application to sub national-scale studies; however, there may be merit in exploring the coincidence of these areas with existing schemes to help build the evidence base.

Indicator D2: Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations

Monitoring question (national-scale): What is the total area of all matrix options in areas of projected high or low species turnover?

Data

Maps at the 10 km resolution showing rates of protected species turnover are available. These maps provide a measure of species turnover, by taxa, using three commonly used, but different, measures (Whittaker, Sorensen and Simpson). The colonisation of non-native species e.g. species from mainland Europe, are not considered. Only matrix options that focus on the maintenance, restoration or creation of habitats should be considered. In total, 176 relevant options (see Appendix D) were identified using the Excel tool (see Section 3.1.1.2). Relatively low spatial resolution limits application of these datasets to sub national-scale studies.

Table 3-32 Excel tool filtering – Adaptation indicator D2

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation, Restoration
Option groups	Exclude Fencing, Historic & landscape, Soil protection
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-33 RAG assessment (data) – Adaptation indicator D2

Level of confidence in the data	Justification
Low	Maps at the 10 km resolution showing rates of protected species turnover are available. These maps provide a measure of species turnover. They are based on climate envelope modelling of existing UK species and exclude potential new arrivals.

Monitoring question (national-scale): What is the total area of all options in areas of projected high or low species turnover?

Data

Maps at the 10 km resolution showing rates of projected species turnover were produced by the University of York for Natural England based on the outputs from a project modelling potential species range change (Pearce Higgins *et al.*, 2015). This projects potential changes in the range, with climate change, of 3048 native species from a variety of taxa for which sufficient distribution data were available. Non- native species which could spread from continental Europe were not included, which means that turnover in the south particularly is likely to be significantly underestimated. These maps provide a measure of species turnover, by taxa, using three commonly used, but different, measures (Whittaker, Sorensen and Simpson). Only core options that focus on the maintenance and restoration of habitats should be considered. In total, there are 34 relevant options identified (see Appendix D), including Woodland Management and Woodland Regeneration Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-34 Excel tool filtering – Adaptation indicator D2

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Maintenance, Restoration
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-35 RAG assessment (data) – Adaptation indicator D2

Level of confidence in the data	Justification
Low	Maps at 10 km x 10 km resolution showing rates of protected species turnover are available. These maps provide a measure of species turnover. They are based on climate envelope modelling of existing UK species and exclude potential new arrivals.

E. Restoring ecosystems

Indicator E1: Creation and restoration options will be focused within areas supporting the Outcome 1D objective

Monitoring question (national-scale): What is the proportion and total area of Outcome 1D potential areas covered by creation and restoration options?

Data

A number of factors were considered to identify areas of habitat potential for each priority habitat, using combinations of suitable soil types, slope conditions and floodplain locations. The approach is similar to that used in the RSPB's Wetland Vision project (Hume, 2008). However, there are some differences in the methods used to derive potential suitable areas for groundwater-fed fens so the implication is that some potentially suitably areas are omitted from the 1D dataset (Amec, 2013).

A series of maps that delineate areas of habitat potential for a range of priority habitats are available (including blanket bog, coastal saltmarsh, coastal sand dune, coastal vegetated shingle, fen, lowland raised bog and reedbed). For each habitat potential map a range of factors (e.g. soils, hydrology, slope, location etc.) have been considered to help identify those areas best able to support each habitat type. Only core options that focus on the creation or restoration of habitats should be considered. In total, there were 20 relevant options identified (see Appendix D) using the Excel tool (see Section 3.1.1.2).

Table 3-36 Excel tool filtering – Adaptation indicator E1

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation, Restoration
Option groups	Fen, Grassland, Heathland, Raised Bog, Reedbed, Saltmarsh, Sand dune, Upland, Vegetated shingle
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-37 RAG assessment (data) – Adaptation indicator E1

Level of confidence in the data	Justification
High	Data is available and quality checked.

F. Making species populations more resilient

Indicator F1: Creation options around existing semi-natural areas will create larger conservation sites

This is a similar adaptation indicator to adaptation indicator B6 except that it considers habitat creation within various distances (abutting, <0.5 km, <1 km and >1 km) of existing priority habitats.

Monitoring question (national-scale): What is the proportion and total area of creation options abutting existing habitat and within 0.5 km, 1 km and >1 km of existing priority habitats?

Data

UK BAP priority habitats and agri-environment scheme (ES) data are required, both of which are widely available and regularly updated. Only creation options that focus on core habitat creation should be considered. In total, there were 17 relevant options identified (see Appendix D), including Woodland Creation Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-38 Excel tool filtering – Adaptation indicator F1

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-39 RAG assessment (data) – Adaptation indicator F1

Level of confidence in the data	Justification
Medium	The underpinning spatial data is available, quality checked and regularly updated. The available point centroid data provides a good estimate for the assessment, but fully georeferenced data would enhance the resolution of the analysis.

Indicator F2: Creation options increase the topographic heterogeneity of habitats

Maintaining environmental heterogeneity by protecting and creating a range of topographic features, soil types and vegetation structures are likely to increase the resilience of conservation sites (Natural England and RSPB, 2014). This is an important adaptation principle relevant to improving ecological resilience to climate change. Creation options support the development of a wide range of important habitat types and, as such, we may also expect them to be coincident with a mixture of priority habitats.

Monitoring question (national-scale): Do creation options increase the topographic heterogeneity of semi-natural habitat?

Data

UK BAP priority habitats and agri-environment scheme (ES) data are required, both of which are widely available and regularly updated. Only those options which support habitat creation should be considered. In total, there are 13 relevant options identified (see Appendix D), including Woodland Creation Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-40 Excel tool filtering – Adaptation indicator F2

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-41 RAG assessment (data) – Adaptation indicator F2

Level of confidence in the data	Justification
High	High resolution data on topography exists and is available. However, establishing the degree to which agri-environment schemes support (or not) changes in topographic range and variability is less clear.

G. Improving water quality and reducing flood risk

Indicator G1: Matrix options for soil protection will be focused in Water Quality Priority Areas

Monitoring question (national-scale): What is the proportion and total area of Water Quality Priority Areas covered by appropriate matrix options?

Data

Natural England and the Environment Agency have produced a dataset that identifies land areas that represent the greatest opportunity for improving water quality; this dataset has been used in targeting agri-environment schemes under CS. The areas have been scored based on seven different water quality issues including groundwaters and rivers at risk from nitrate pollution, groundwaters and rivers at risk of pesticide pollution, faecal indicators, sediment risks and phosphate risks.

The Water Quality Priority Areas dataset is available and has been used in targeting agri-environment schemes. Only matrix options that focus on the maintenance, restoration or creation of habitats should be considered. In total, there are 112 relevant options (see Appendix D) identified using input from the Steering Group. Filtering using the Excel tool was not able to be applied in this case due to the contribution of a range of different options to improving water quality.

Table 3-42 Excel tool filtering – Adaptation indicator G1

Filter	Selection
Type	Not applicable – manually selected
Core/Matrix	Not applicable – manually selected
Initial grouping	Not applicable – manually selected
Option groups	Not applicable – manually selected
Habitat	Not applicable – manually selected
Sub-target	Not applicable – manually selected
Geometry	Not applicable – manually selected
Include	Not applicable – manually selected

Table 3-43 RAG assessment (data) – Adaptation indicator G1

Level of confidence in the data	Justification
Medium	Spatial information on water quality areas are available. The ability of different agri-environment scheme options to contribute to specific water quality objectives will be dependent on local conditions.

Indicator G2: There will be a greater concentration of relevant agri-environment scheme options within flood prone areas to reduce flood risk

The Environment Agency's Flood Risk Zones (also commonly referred to as 'Flood zones 2 and 3') depict areas across England and Wales that could be affected by flooding from rivers or the sea at two return periods: 1 in 1000 years (Zone 3) and 1 in 100 years (Zone 2).

Monitoring question (national-scale): What is the proportion of options within/outside of flood zones 2 and 3?

Data

The EA's Flood Risk Zones are widely available and updated on a quarterly basis. Only creation, restoration and maintenance options that have a focus on reducing flood risk should be considered (see Appendix D). In total, there are 10 relevant core creation options identified using the Excel tool (see Section 3.1.1.2).

Table 3-44 Excel tool filtering – Adaptation indicator G2

Filter	Selection
Type	Option
Core/Matrix	-
Initial grouping	Creation, Maintenance, Restoration
Option groups	-
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-45 RAG assessment (data) – Adaptation indicator G2

Level of confidence in the data	Justification
Low	Appropriate option selection is likely to be dependent on place-based issues and therefore likely to be highly specific. A national-scale analysis is unlikely to pick up anything more than general patterns.

Indicator G3: Agri-environment schemes will support the objectives of the Woodlands for Water programme

Monitoring question (national-scale): What is the proportion and total area of appropriate options supporting objectives of the Woodlands for Water programme?

Data

Opportunity maps have been produced by the Environment Agency to identify areas that may benefit from woodland habitat creation. Unfortunately, due to licensing issues, we were unable to access the data for the purposes of this project.

Only options that focus on the maintenance, restoration and creation of woodland should be considered. In total, there are 22 relevant options identified (see Appendix D), including Woodland Creation, Woodland Management and Woodland Regeneration Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-46 Excel tool filtering – Adaptation indicator G3

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation, Maintenance, Restoration
Option groups	Trees & Woodland
Habitat	-
Sub-target	-
Geometry	Area, Linear, Point
Include	Yes

Table 3-47 RAG assessment (data) – Adaptation indicator G3

Level of confidence in the data	Justification
Low	Unfortunately, due to licensing issues, we were unable to gain access to this dataset and use it in this project.

H. Storing and sequestering carbon

Indicator H1: Agri-environment schemes contribute to the storage and sequestration of carbon

Monitoring question (national-scale): What is the proportion (and area) of blanket peat and peat soils with appropriate options on?

Data

Natural England have developed spatially explicit data layers for carbon storage and sequestration. The Carbon Storage data layer highlights the amount of carbon stored in the soil along with an assessment of the likely loss over time due to historical land use change. An area of peat (the soils with the highest carbon content) that has been under semi-natural habitat will have lost very little carbon to the atmosphere when compared to a similar soil converted to arable cultivation 100 years ago.

Carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide (CO_2). This data layer has mapped out where the most potential for land use change occurs, so that CS options can lock in greater amounts of carbon back into the soil for the long term. This is created from a combination of areas with high carbon soils but that are being managed in a way that releases large amounts of carbon to the atmosphere due their dry state. These high carbon areas were created in waterlogged conditions which prevented oxidation of the soil and so built up carbon over 1,000 years. Significant reduction of emissions can still be achieved without going back to waterlogged conditions (although this is ideal) by moving from a land use with high emissions to one in a lower emissions state.

The classifications within each layer are H (high), M (medium) and L (low) which represent the following:

Carbon Storage:

- H – Represents the presence of a peat based soil of significant depth, probably due to only a small amount of disturbance over time;
- M – is where the parcel has a peat soil of depth but will have had land management practices that have reduced the carbon storage capacity; or
- L – Lower initial carbon in soil (none peat soil) or severely affected by carbon loss over the last centuries.

Carbon Sequestration:

- H – Areas that are losing carbon to the atmosphere at a very high rate (arable peatland areas) and so have the potential through a change in land use to reduce emission to a lower state;
- M – Areas with moderate carbon loss with potential to change with slightly lower emission reductions (improved grassland over peatland soils); or
- L – Areas with high carbon storage but already in a land use that will be reducing emissions loss.

Only creation, restoration and maintenance options that focus on core habitat should be considered (see Appendix D). In total, there are 27 relevant core creation options identified using the Excel tool (see Section 3.1.1.2).

Table 3-48 Excel tool filtering – Adaptation indicator H1

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation, Maintenance, Restoration
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-49 RAG assessment (data) – Adaptation indicator H1

Level of confidence in the data	Justification
High	The underpinning spatial data has been developed to highlight both storage and sequestration potential.

I. Targeting and applying interventions in a cost-effective and adaptive way

Indicator I1: Adaptation in the natural environment will be consistent with agricultural adaptation

Monitoring question (national-scale): What is the area of core habitat creation options within each Agricultural Land Classification (ALC) grade?

Data

ALC data is readily available and widely used. Only creation options that focus on core habitat should be considered (see Appendix D). In total, there are 19 relevant core creation options identified, including Woodland Creation Grants, using the Excel tool (see Section 3.1.1.2).

Table 3-50 Excel tool filtering – Adaptation indicator I1

Filter	Selection
Type	Option
Core/Matrix	Core
Initial grouping	Creation
Option groups	Grassland, Heathland, Inter-tidal & Coastal, Trees & Woodland, Upland, Wetland
Habitat	-
Sub-target	-
Geometry	Area
Include	Yes

Table 3-51 RAG assessment (data) – Adaptation indicator I1

Level of confidence in the data	Justification
High	All data is widely available and quality checked.

Indicator I2: Options will be implemented in a flexible way to facilitate adaptive management

Monitoring question (national-scale): Does the scheme design and architecture enable a flexible approach to delivering adaptation indicators?

Data

Spatial uptake data will not adequately assess the ability of options (including objective setting, option deployment and prescription setting) to deliver this indicator. This assessment should be delivered at local scales.

It is recommended that a national assessment should consist of a qualitative review of scheme design and operation through a review of published scheme literature and a series of structured interviews with interviews covering the design and operation of the schemes to ensure that flexibility is built into the scheme at an early stage.

Indicator I3: Agri-environment options will accommodate change where appropriate

Monitoring question (national-scale): Does the scheme design and architecture enable environmental change to be accommodated?

Data

As with indicator I2, spatial uptake data will not adequately assess the ability of options (including objective setting, option deployment and prescription setting) to deliver this indicator. However, it is likely that these data may be captured at a local scale working with farmers/land managers.

National assessment will consist of a qualitative review of scheme design and operation through a review of published scheme literature and a series of structured interviews with interviews covering the design and operation of the schemes.

3.1.1.4. Summary of the final set of adaptation indicators

Table 3-52 lists the adaptation indicators selected for developing the national-scale element of the monitoring framework and that will later be used for the baseline assessment (Section 4). This selection was informed by the assessment made in Section 2. Appendix D provides a detailed list of the options that were selected using the Excel tool for each indicator.

Table 3-52 Full list of adaptation indicators, showing the final subset of indicators and corresponding monitoring questions selected for the national-scale assessment. Indicators shown in grey were not selected for national-scale assessment (either because of data issues or because they duplicated another indicator) but in many cases are still relevant for farm-level monitoring (see Section 5).

Category	Adaptation indicator	Monitoring question
A. Protecting the most important and vulnerable sites	A1. Maintenance and restoration options will be coincident with priority habitats	What is the proportion of priority habitat covered by Maintenance and Restoration options?
	A2. The condition of priority habitat under agri-environment schemes will be higher than that of priority habitat not under agri-environment schemes	What is the proportion of priority habitat covered by maintenance and restoration options?
	A3. Agri-environment schemes will support SSSIs	What is the proportion and total area of SSSIs covered by maintenance and restoration options?
	A4. Restoration and maintenance options will support highly sensitive habitats	Of habitats with High, Medium or Low (and 1-5) sensitivities, what is the proportion under appropriate restoration and maintenance options?
	A5. Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)	What is the area of creation option uptake by sensitivity class?
	A6. Agri-environment scheme management will create shade for rivers where this is a priority for the freshwater habitat	What is the total area of created habitat within riparian shade zones?
B. Reducing fragmentation and enhancing ecological networks	B1. Creation options will reduce fragmentation	What is the proportion and total area of appropriate creation options in each fragmentation buffer?
	B2. Restoration options will support the reduction of fragmentation	What is the proportion and total area of appropriate creation options in each fragmentation buffer?
	B3. Woodland creation options will help to reduce woodland fragmentation	What is the proportion and total area of appropriate restoration options in each fragmentation area?
	B4. Woodland restoration and maintenance options will support the reduction of woodland fragmentation	What is the proportion and total area of appropriate woodland creation options within each fragmentation band (just for woodland fragmentation)?
	B5. Matrix options to restore or create features should be focussed in areas of high fragmentation	What is the proportion and total area of appropriate creation and restoration matrix options in the high fragmentation buffer?
	B6. Creation options will enhance ecological networks	What is the proportion and total area of appropriate creation and restoration matrix options in the high fragmentation buffer?
	B7. Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species	What is the proportion of appropriate woodland creation options that fall within 1 km of woodland habitat networks?

Category	Adaptation indicator	Monitoring question
C. Protecting refugia	C1. Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia	What is the area of appropriate creation, maintenance or restoration options in areas of high and low refugia?
D. Planning for potential changes in species' ranges and assemblages	D1. Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions	What is the total area of appropriate options in relation to the priority areas of future ranges of taxa?
	D2. Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations	What is the total area of appropriate options in relation to the priority areas of future ranges of taxa?
E. Restoring ecosystems	E1. Creation and restoration options will be focused within areas supporting the Outcome 1D objective	What is the proportion and total area of Outcome 1D potential areas covered by creation and restoration options?
F. Making species populations more resilient	F1. Creation options around existing semi-natural areas will create larger conservation sites	What is the proportion and total area of creation options abutting existing habitat and within 0.5 km, <1 km and >1 km of existing priority habitats?
	F2. Creation options increase the topographic heterogeneity of habitats	What is the proportion and total area of creation options abutting existing habitat and within 0.5 km, <1 km and >1 km of existing priority habitats?
G. Improving water quality and reducing flood risk	G1. Matrix options for soil protection will be focused in Water Quality Priority Areas	What is the proportion and total area of Water Quality Priority Areas covered by appropriate matrix options?
	G2. There will be a greater concentration of relevant agri-environment schemes options within flood prone areas to reduce flood risk	What is the proportion and total area of Water Quality Priority Areas covered by appropriate matrix options?
	G3. Agri-environment schemes will support the objectives of the Woodlands for Water programme	What is the proportion of options within/outside of flood zones 2 and 3?
H. Storing and sequestering carbon	H1. Agri-environment schemes contribute to the storage and sequestration of carbon	What is the proportion (and area) of blanket peat and peat soils with appropriate options on?
I. Targeting and applying interventions in a cost-effective and adaptive way	I1. Adaptation in the natural environment will be consistent with agricultural adaptation	What is the area of core habitat creation options within each Agricultural Land Classification (ALC) grade?
	I2. Options will be implemented in a flexible way to facilitate adaptive management	Does the scheme design and architecture a flexible approach to delivering adaptation indicators?
	I3. Agri-environment options will accommodate change where appropriate	Does the scheme design and architecture enable environmental change to be accommodated?

4. Results of the national-scale baseline assessment

The second objective of this project (see Section 1.3) was to develop a baseline assessment from which future change will be able to be compared. As part of developing this baseline, a set of adaptation indicators, representing adaptation that we might expect to be delivered through agri-environment schemes, were developed and reviewed (Section 2) before a final set were proposed for monitoring at the national-scale (Table 3-52). This section presents the results of the baseline assessment. The results are described by each of the final adaptation indicators (see Table 3-52) in turn. Also, where appropriate, complete results are presented in Appendix E.

In most cases, to generate the results, each of the relevant options (see Appendix D) for each of the adaptation indicators identified above were firstly selected using the Excel tool (Section 3.1.1.2). A GIS was then used to link the selected options from the Excel tool to the ES options point data (see Section 3.1.1.1). The selected option points (comprising different types of options depending upon the adaptation indicator in question) were then analysed against a range of datasets and, in most cases, total areas (in hectares) for all relevant options summed. In some cases, proportions (representing coverage over an area) were also calculated (e.g. % of priority habitat covered by maintenance and restoration options). Finally, land parcels that are not eligible to receive agri-environment scheme funding were screened out so that these areas were not included in the reported statistics.

By way of an example, in the case of adaptation indicator A1 (Maintenance and restoration options will be coincident with priority habitats), the question we were trying to test was as follows: *What is the proportion of priority habitat covered by Maintenance and Restoration options?* To do this, the Excel tool was used to identify options relevant to the maintenance and restoration of priority habitats. In total, 34 relevant options, including Woodland Management and Restoration Grants, were identified (see Appendix D). The selected options were then identified in the ES option points data using a simple table join (based on the option code) in the GIS. The selected option points were then queried against the priority habitat data for England and the total area (in hectares) for those points that intersected, summed. Finally, all priority habitat that fell outside of the UAA was omitted, alongside any option points that also were located within these areas. The result of this particular analysis is the total area (ha) of maintenance and restoration options located within areas of priority habitat. This type of analysis was repeated, as necessary, for each of the final adaptation indicators identified above.

The sub-sections that follow presents the results of the national-scale baseline assessment.

A. Protecting the most important and vulnerable sites

Indicator A1: Maintenance and restoration options will be coincident with priority habitats

Monitoring question (national-scale): What is the proportion of priority habitat covered by the selected maintenance and restoration options?

Summary of result: On average, across all priority habitats within England, around half (~49%) of priority habitats eligible for agri-environment schemes are covered by the selected maintenance and restoration options. Across England, ~79% of priority habitats are located within the eligible area.

Table 4-1 shows the total area (in hectares) of priority habitat in England, the total area (in hectares) of priority habitat that is located within the UAA and the coverage (in hectares) of maintenance and restoration options for each priority habitat within the UAA. The proportion of each priority habitat within the UAA covered by maintenance and restoration options is also provided. Figure 4-1 shows, for each 10 km x 10 km grid in England, the proportion of each grid that is covered by priority habitat; whilst Figure 4-2 shows the proportion of priority habitats within the UAA within each 10 km x 10 km grid. Figure 4-3 shows the total area (in hectares) of the selected maintenance and restoration options, within the UAA within each 10 km x 10 km grid. Figure 4-4 shows the proportion of priority habitats, within the UAA, covered by the selected maintenance and restoration options. The grids with the greatest area of maintenance and restoration options (within the UAA) are concentrated in the uplands of the North and South West and the area around Purbeck and the New Forest in the south.

Figure 4-1 Proportion of priority habitats within 10 km x 10 km grids in England

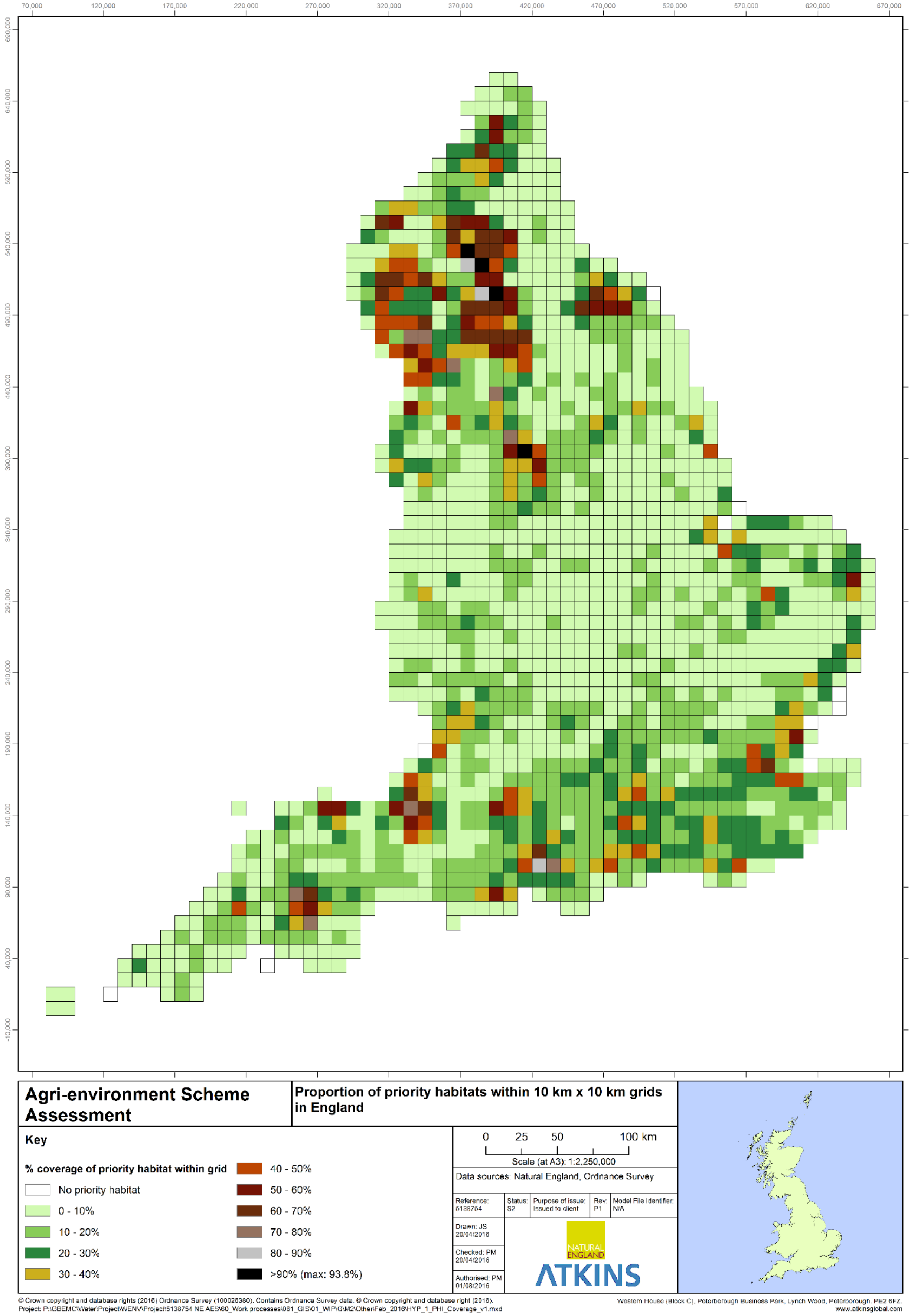
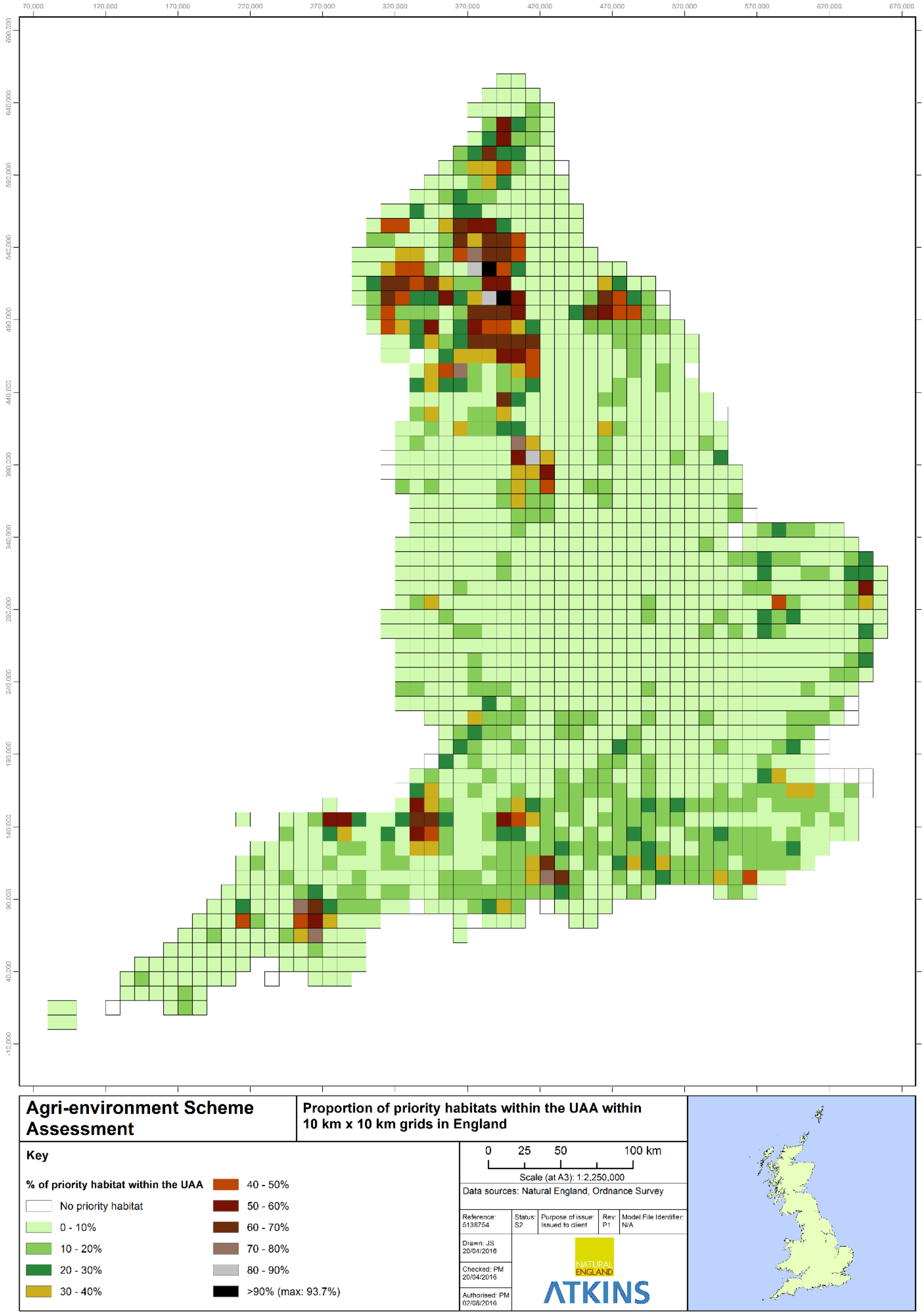


Figure 4-2 Proportion of priority habitats within the UAA within 10 km x 10 km grids in England



Project: P:\GBEMC\Water\Project\WENV\Project\5138754 NE AES\60_Work processes\061_GIS\01_WIP\G\M2\Other\Feb_2016\HYP_1_PHI_UAA_Coverage_v1.mxd

Western House (Block C), Peterborough Business Park, Lynch Wood, Peterborough. PE2 6FZ.
www.atkinsglobal.com

Figure 4-3 Total area of maintenance and restoration options, within the UAA, within 10 km x 10 km grids in England

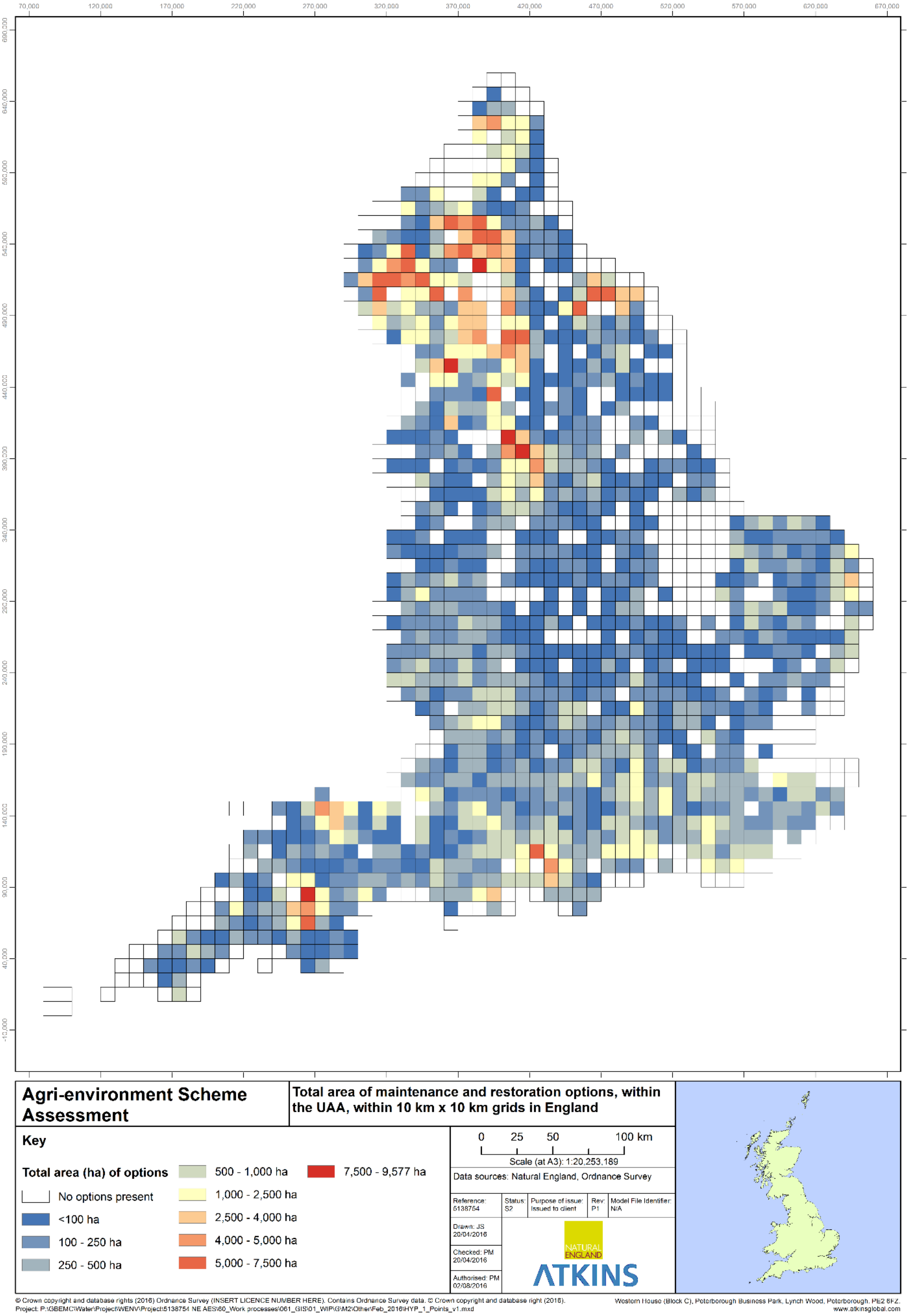
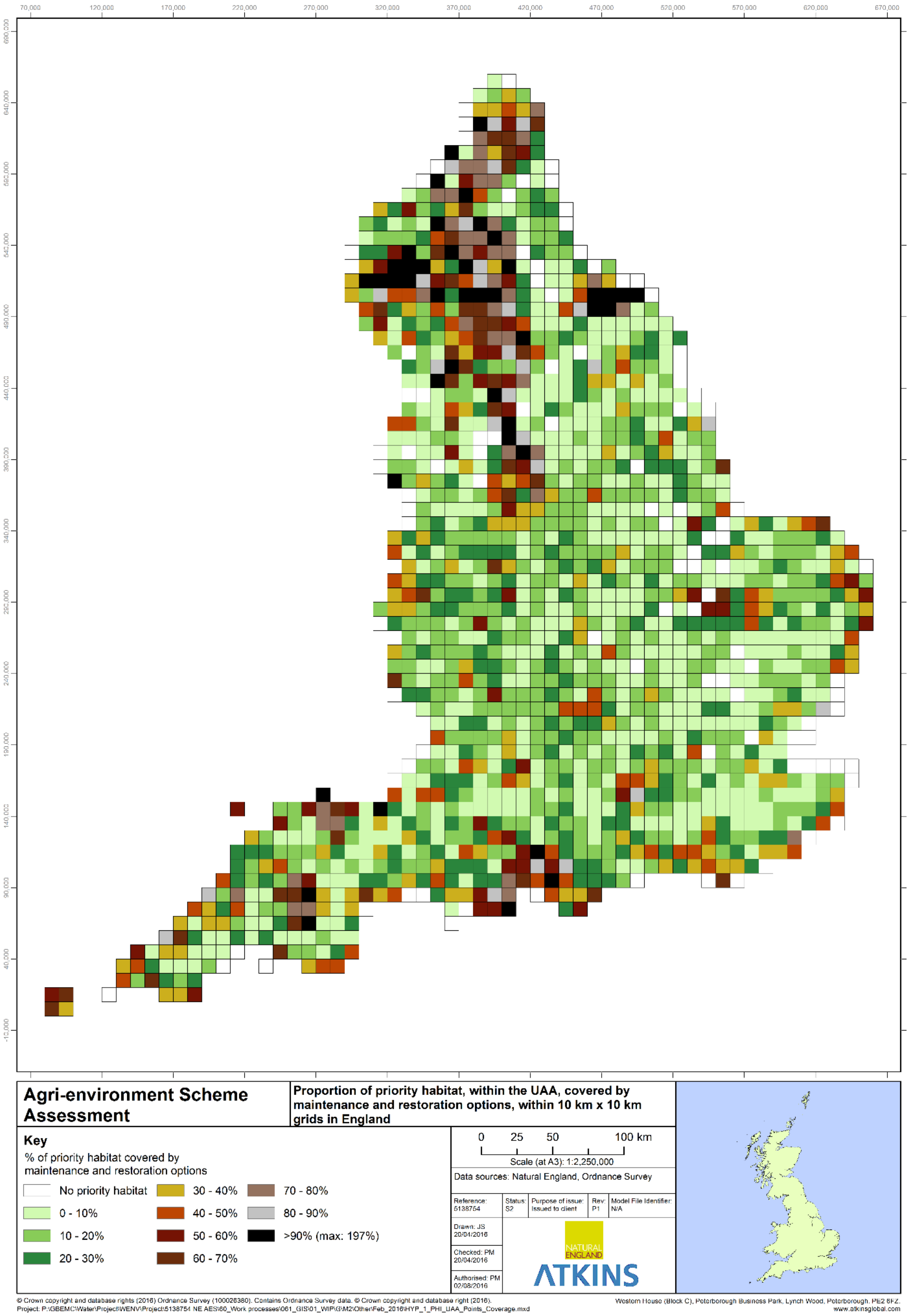


Figure 4-4 Proportion of priority habitat, within the UAA, covered by maintenance and restoration options, within 10 km x 10 km grids in England



The tabular results indicate that deciduous woodland (734,958 ha) is the priority habitat with the greatest coverage in England. ‘No main habitat but additional habitats exist’ covers the second greatest area (486,672 ha); as the name suggests, these areas contain a mixture of smaller habitat patches where no clear primary habitat is evident. Upland heathland (230,570 ha), blanket bog (229,983 ha) and coastal and floodplain grazing marsh (218,273 ha) all have similar coverage in England.

Priority habitat coverage within the UAA follows a similar pattern to that described above, possibly due to the relative abundance of these habitat types; it also reflects what is in/outside of the UAA. Deciduous woodland (441,939 ha, 60.1% within UAA) covers the greatest total area of UAA, followed by areas with no main habitat (324,357 ha, 66.6% within UAA), upland heathland (225,819 ha, 97.9% within UAA), blanket bog (223,719 ha, 97.3% within UAA) and coastal and floodplain grazing marsh (201,136 ha, 92.1% within UAA). Looking instead at the proportion of priority habitats within the UAA against their total land area, all areas of fragmented heath (5,742 ha, 100% within UAA) are located within the UAA. Of the 29 priority habitats listed in Table 4-1, over 55% (16) have more than 90% of their total land areas located within the UAA, over 65% (19) have more than 80% of their land areas located within the UAA and nearly 90% (26) have over 50% of their land areas located within the UAA. Mudflats (6,865 ha, 9.9% within the UAA) and saline lagoons (356 ha, 26.4% within the UAA) contain the lowest proportions of their total land areas within the UAA and therefore may be difficult to manage using agri-environment schemes.

The coverage of priority habitat eligible for agri-environment management (i.e. land parcels within the UAA) by the selected maintenance and restoration options, across all priority habitats the average coverage of maintenance and restoration options is 49% (max=92%, min=0%), with blanket bog (92%) having the greatest coverage, followed by upland heathland (88%) and upland hay meadows (86%). In contrast, coverage is poor over mudflats (4%) and saline lagoons (12%) although relatively small amounts of these priority habitat types are located within the UAA (9.9% and 26.4%, respectively). Noteworthy is the relatively low coverage (42%) of maintenance and restoration options over lowland calcareous grasslands. This is, in part, due to large areas of this habitat being located within eligible areas (i.e. within the UAA) but with other restrictions that apply. For example, large areas are located in the Salisbury Plains where access is restricted by the Ministry of Defence.

Table 4-1 Total area of priority habitat in England, within the UAA and coverage by selected maintenance and restoration options

Priority habitat	Total area (ha) of priority habitat in England	Total area (ha) of priority habitat within the UAA	% of priority habitat within the UAA	Total area (ha) of each priority habitat within the UAA covered by selected M and R options	% of each priority habitat within UAA covered by selected M and R options
Blanket bog	229,983	223,719	97.3%	205,326	92%
Calaminarian grassland	152	139	91.4%	82	59%
Coastal and FGM	218,273	201,136	92.1%	40,055	20%
Coastal saltmarsh	33,287	22,860	68.7%	12,098	53%
Coastal sand dunes	9,996	6,139	61.4%	3,894	63%
Coastal vegetated shingle	4,103	2,042	49.8%	776	38%
Deciduous woodland	734,958	441,939	60.1%	143,800	33%
Fragmented heath	5,743	5,742	100.0%	4,681	82%
Good quality semi-improved grassland	52,372	47,328	90.4%	18,836	40%
Grass moorland	18,986	18,247	96.1%	9,340	51%
Limestone pavement	1,166	1,057	90.6%	169	16%
Lowland calcareous grassland	57,174	51,810	90.6%	21,874	42%
Lowland dry acid grassland	14,880	13,116	88.1%	7,839	60%
Lowland fens	20,798	17,569	84.5%	8,040	46%
Lowland heathland	50,973	46,621	91.5%	36,678	79%
Lowland meadows	18,007	16,848	93.6%	10,782	64%
Lowland raised bog	9,090	4,542	50.0%	2,272	50%
Maritime cliff and slope	14,082	8,418	59.8%	3,338	40%
Mountain heaths and willow scrub	1,407	1,359	96.6%	0	0%
Mudflats	69,377	6,865	9.9%	268	4%
No main habitat but additional habitats exist	486,672	324,357	66.6%	99,323	31%
Purple moor grass and rush pastures	7,117	6,829	96.0%	4,006	59%
Reedbeds	2,954	2,547	86.2%	1,669	66%
Saline lagoons	1,349	356	26.4%	41	12%
Traditional orchard	14,853	9,628	64.8%	1,556	16%
Upland calcareous grassland	11,177	11,117	99.5%	7,449	67%
Upland flushes, fens and swamps	13,509	13,356	98.9%	8,301	62%

Priority habitat	Total area (ha) of priority habitat in England	Total area (ha) of priority habitat within the UAA	% of priority habitat within the UAA	Total area (ha) of each priority habitat within the UAA covered by selected M and R options	% of each priority habitat within UAA covered by selected M and R options
Upland hay meadow	1,909	1,891	99.1%	1,621	86%
Upland heathland	230,570	225,819	97.9%	197,963	88%
Mean	80,514	59,772	79.2%	29,382	48.8%
Min	152	139	9.9%	0	0%
Max	734,958	441,939	100%	205,326	91.8%
Total	2,334,916	1,733,395	n/a	852,080	n/a

Table E-1 shows the total area (in hectares) of uptake of each of the 34-relevant maintenance and restoration options for each priority habitat. In total, across all 34 maintenance and restoration options, there are 852,036 ha of uptake across the 29 priority habitat types.

HL10 (restoration of moorland) covers the greatest total area (397,394 ha, 46.6% of total uptake across all 34 options) and is found on blanket bog (173,546 ha or 43.7% of HL10 uptake), upland heathland (133,535 ha or 33.6% of HL10 uptake) and no main habitat (62,888 ha, 15.8% of HL10 uptake). HL9 (maintenance of moorland) covers the second greatest total area (103,332 ha or 12.1% of total uptake across all 34 options) and is found on upland heathland (63,548 ha or 61.5% of HL9 uptake) and blanket bog (31,213 ha or 30.2% of HL9 uptake). WMG covers the third greatest total area (90,934 ha, 10.7% of total uptake across all 34 options) and is found on deciduous woodland (85,197 ha or 93.7% of WMG uptake) and no main habitat (3,889 ha or 4.3% of WMG uptake). All of the other 31 options not mentioned show total uptake of less than 5% of the total area.

Table E-2 breaks down the analysis by NCAs. It shows the total area (in hectares) of UAA, priority habitat and option uptake within each NCA. The North Pennines (NCA 428) contains the greatest total area of priority habitat (130,293 ha, 6.1% of all priority habitat in England), followed by the Yorkshire Dales (NCA 399) (129,491 ha, 6.0% of all priority habitat in England) and Cumbria High Fens (NCA 343) (82,668 ha, 3.8% of all priority habitat in England). The same is also similar when looking at the total area of priority habitat within the UAA within each NCA, probably due to the relatively large sizes of the NCAs. The Yorkshire Dales (NCA 399) contains 127,233 ha, (98.2% of priority habitat is within the UAA) followed by the North Pennines (NCA 428) which contains 125,746 ha (96.5% of priority habitat is within the UAA). Conversely, the Isle of Portland (NCA 137) (135 ha) and Lundy (NCA 159) (321 ha) contains the least. Highly urbanised areas, including Inner London (NCA 112), Manchester Conurbation (NCA 55) and Merseyside Conurbation (NCA 58), contain relatively small amounts of priority habitat within the UAA at 485 ha, 618 ha and 635 ha respectively.

In terms of uptake of maintenance and restoration options within the NCAs, North Pennines (NCA 10) contains the greatest area (107,179 ha) followed by Yorkshire Dales (NCA 21) (97,641 ha) and Cumbria High Fells (NCA 8) (89,227 ha). Carnmenellis (NCA 155) (72 ha), Merseyside Conurbation (NCA 58) (83 ha) and North East Norfolk and Flegg (NCA 79) (140 ha) contains the least. Some NCAs, notably Greater Thames Estuary (NCA 81), Manchester Conurbation (NCA 55), Isles of Scilly (NCA 158), Lundy (NCA 159) and Isle of Portland (NCA 137), contain no options.

As a proportion of all priority habitat within the UAA covered by maintenance and restoration options, Howgill Fells (NCA 537) and Cumbria High Fells (NCA 343) has the equal greatest proportion (110.7%) of priority habitat covered by options (2,902 ha of 2,620 ha and 89,227 ha of 80,627 ha, respectively). These values are greater than 100% due to the method (and data) by which the results have been calculated. The total area from agri-environment scheme point data have been summed within each NCA, however, where points lie at or very close to the boundary of an NCA the point (and associated area) is summed for that NCA. Therefore, results may exceed 100% of the total area in some circumstances. The alternative, using polygonised data, is too computationally intensive to calculate at the national-scale and has therefore been omitted here.

The Vale of Pickering (NCA 374) (6%, 444 ha of 7,381 ha) has the least, followed by Lancaster and Amounderness Plain (NCA 512) (7.5%, 1,139 ha of 15,258 ha) and the Vale of Mowbray (NCA 442) (8.1%, 156 ha of 1,938 ha). The average proportion of priority habitat within the UAA covered by the selected maintenance and restoration options across all NCAs is 41.5% (min=0%, max=110.7%). Note, this value is different to that provided in Table 4-1 (48.8%) due to NCA boundaries being restricted to land areas only whereas priority habitat (and UAA) may be found outside of these areas (e.g. coastal mudflat and coastal saltmarsh are frequently located outside of NCA boundaries).

Indicator A3: Agri-environment schemes will support SSSIs

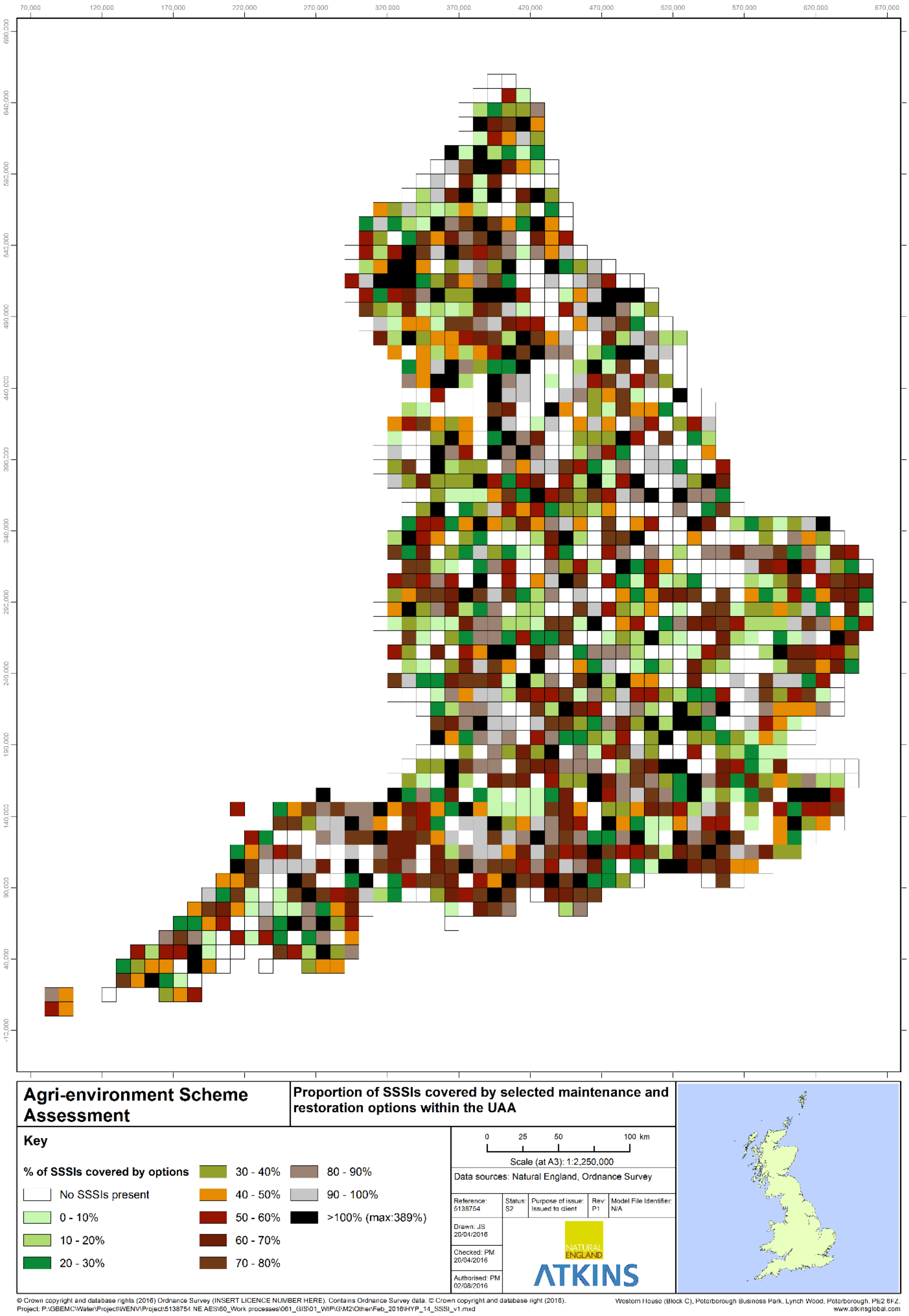
Monitoring question (national-scale): What is the proportion and total area of SSSIs covered by selected maintenance and restoration options?

Summary of result: Point agri-environment data is not of a sufficient resolution to draw conclusions regarding the proportion of SSSIs covered by selected maintenance and restoration options. The analysis presented here sums the total area of these options that are located within the SSSIs and calculates a proportional coverage. This is misleading in this particular case as the land area in agreement (represented by a single point) may or may not wholly cover the SSSIs and therefore only part of the SSSI may actually be covered by a selected maintenance and/or restoration option. As a result, the outputs presented here should be treated with caution. Fully georeferenced data (output from GENESIS) is required. This indicator will be best monitored at the farm-scale.

Figure 4-5 shows the proportion of SSSIs within each 10 km x 10 km grid covered by selected maintenance and restoration options. The large values may be explained by the relatively small land areas that SSSIs occupy within each grid and the (relatively) large amount of land covered by maintenance and restoration options. As a result, the proportional coverage of options within SSSIs is difficult to decipher at the national-scale. For example, there are many instances where maintenance and restoration options (represented as individual points in the GIS data) are found to be located within SSSIs. The analysis presented here sums the total area of these options that are located within the SSSIs and calculates a proportional coverage. This is misleading in this particular case as the land area in agreement (represented by a point) may or may not wholly cover the SSSIs and therefore only part of the SSSI may be covered by an option. As a result, the outputs presented here should be treated with caution.

Fully georefenced data (to the field parcel level), as output from GENESIS, are required to assess this particular adaptation indicator at the national-scale. At present, the coverage of SSSIs by selected maintenance and restoration options cannot be reliably assessed at the national-scale.

Figure 4-5 Proportion of SSSIs covered by selected maintenance and restoration options within the UAA



Indicator A4: Restoration and maintenance options will support highly sensitive habitats

Monitoring question (national-scale): Of habitats with High, Medium or Low (and 1-5) sensitivities, what is the proportion under appropriate restoration and maintenance options?

Summary of result: The majority of restoration and maintenance option uptake is on habitats with a medium sensitivity (56.1% or 477,703 ha) using the sensitivity classification adopted in the NBCCVA study; there is significantly less uptake on habitats with High (7% or 59,425 ha) and Low sensitivities (21.4% or 182,689 ha). Using our own classification, a similar trend is evidence with the majority of uptake on habitats with sensitivities in bands 2 (25.3% or 215,162 ha) and 3 (33.9% or 288,771 ha) and less in band 1 (4.3% or 36,488), band 4 (19% or 162,283) and band 5 (5.9% or 50,106 ha).

Table 4-2 shows the total area of different priority habitats within England, the proportion (and total area) within the UAA and the total area (and proportion) of uptake of selected maintenance and restoration options within each priority habitat. Two types of habitat sensitivity are also shown, notably that used in the NBCCVA study and those derived by the Steering Group for this study (see Appendix C).

In terms of their location, the majority of priority habitat is located within the UAA (mean=79.2%, min=9.9%, max=100%). On average, across all priority habitats, almost half (~48.8%) of all priority habitat within the UAA is covered by the selected maintenance and restoration options.

Blanket bog (M/2 sensitivity) has the greatest uptake of options (91.8% or 205,326 ha) followed by upland heathland (M/3) (87.5% or 197,684 ha) and upland hay meadow (H/2) (85.7% or 1,620 ha). Uptake is significantly lower on mudflats (M/2) (3.9% or 268 ha) and is non-existent on mountain heath and willow scrub habitat (H/1). In the case of mudflat, this is probably due to this habitat largely existing outside of the UAA and therefore being ineligible for inclusion within agri-environment schemes. This is not true of mountain heath and willow scrub which has a very high proportion (97%) of its total area located within the UAA. However, this particular habitat type is relatively less abundant (1,359 ha within the UAA out of 1,407 ha) compared with mudflat (6,865 ha within the UAA out of 69,377 ha).

Looking now at the uptake of the selected maintenance and restoration options by sensitivity class there are ~1,733,395 ha of priority habitat located within the UAA in England (i.e. the area that is eligible for agri-environment schemes) and there is uptake of maintenance and restoration options covering ~49.2% (~852,080 ha) of this area. Table 4-3 splits this area (852,080 ha) into uptake by sensitivity class. The vast majority (56.1% or 477,703 ha) of uptake of maintenance and restoration options occurs within the medium sensitivity band. Alternatively in the sensitivity categorisation derived by the Steering Group, uptake is split for the majority across band 2 (25.3% or 215,162 ha) and band 3 (33.9% or 288,717 ha).

Table 4-2 Total areas, and proportion, of different priority habitats covered by selected maintenance and restoration options and associated habitat sensitivities

Priority habitat	Total area (ha) of habitat in England	Total area (ha) of habitat in England within UAA	% of habitat within the UAA	Total area (ha) of habitat within UAA covered by maintenance and restoration options and WMG, WRG	(%) of priority habitat within the UAA that is covered by maintenance and restoration options	Habitat sensitivity from NBCCVA	Habitat sensitivity from this project (1-5, where 1=most sensitive)
Blanket bog	229,983	223,719	97%	205,326	91.8%	M	2
Calaminarian grassland	152	139	91%	82	59.4%	N/A	4
Coastal and FGM	218,273	201,136	92%	40,055	19.9%	H	3
Coastal saltmarsh	33,287	22,860	69%	12,098	52.9%	H	1
Coastal sand dunes	9,996	6,139	61%	3,894	63.4%	M	1
Coastal vegetated shingle	4,103	2,042	50%	776	38.0%	M	1
Deciduous woodland	734,958	441,939	60%	143,800	32.5%	L	4
Fragmented heath	5,743	5,742	100%	4,681	81.5%	N/A	3
Good quality semi-improved grassland	52,372	47,328	90%	18,836	39.8%	N/A	5
Grass moorland	18,986	18,247	96%	9,340	51.2%	N/A	3
Limestone pavement	1,166	1,057	91%	169	16.0%	L	4
Lowland calcareous grassland	57,174	51,810	91%	21,874	42.2%	L	5

Priority habitat	Total area (ha) of habitat in England	Total area (ha) of habitat in England within UAA	% of habitat within the UAA	Total area (ha) of habitat within UAA covered by maintenance and restoration options and WMG, WRG	(%) of priority habitat within the UAA that is covered by maintenance and restoration options	Habitat sensitivity from NBCCVA	Habitat sensitivity from this project (1-5, where 1=most sensitive)
Lowland dry acid grassland	14,880	13,116	88%	7,839	59.8%	L	5
Lowland fens	20,798	17,569	84%	8,040	45.8%	M	1
Lowland heathland	50,973	46,621	91%	36,678	78.7%	M	3
Lowland meadows	18,007	16,848	94%	10,782	64.0%	M	4
Lowland raised bog	9,090	4,542	50%	2,272	50.0%	H	2
Maritime cliff and slope	14,082	8,418	60%	3,338	39.7%	H	1
Mountain heaths and willow scrub	1,407	1,359	97%	-	0.0%	H	1
Mudflats	69,377	6,865	10%	268	3.9%	M	2
No main habitat but additional habitats	486,672	324,357	67%	99,323	30.6%	N/A	N/A
Purple moor grass and rush pastures	7,117	6,829	96%	4,006	58.7%	M	2
Reed beds	2,954	2,547	86%	1,669	65.5%	M	2
Saline lagoons	1,349	356	26%	41	11.6%	H	1
Traditional orchard	14,853	9,628	65%	1,556	16.2%	L	5
Upland calcareous grassland	11,177	11,117	99%	7,449	67.0%	L	4
Upland flushes, fens and swamps	13,509	13,356	99%	8,301	62.2%	M	1
Upland hay meadow	1,909	1,891	99%	1,621	85.7%	H	2
Upland heathland	230,570	225,819	98%	197,963	87.7%	M	3
Mean	80,514	59,772	79.2%	29,382	48.8%	n/a	2.8
Min	152	139	9.9%	0	0.0%	n/a	5
Max	734,958	441,939	100.0%	852,080	91.8%	n/a	1
Total	2,334,916	1,733,395	n/a		n/a	n/a	n/a

Table 4-3 Uptake of maintenance and restoration options by habitat sensitivity (H-L)

Sensitivity	Total uptake area (ha) by maintenance and restoration options	% uptake by area
H	59,425	7.0%
M	477,703	56.1%
L	182,689	21.4%
N/A	132,263	15.5%
Total	852,080	100%

Table 4-4 Uptake of maintenance and restoration options by habitat sensitivity (1-5)

Sensitivity	Total uptake area (ha) by maintenance and restoration options	% uptake by area
1	36,488	4.3%
2	215,162	25.3%
3	288,717	33.9%
4	162,283	19.0%
5	50,106	5.9%
N/A	99,323	11.7%
Total	852,080	100%

Indicator A5: Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)

Monitoring question (national-scale): What is the area of creation option uptake by each sensitivity class?

Summary of result: Data on habitat creation at the national level is restricted to broad categories, for example grassland creation. This resolution is too coarse to draw sensible conclusions regarding the ability of agri-environment schemes to compensate for projected losses of different habitats. Farm-scale monitoring will provide the necessary detail to monitor this indicator.

Table 4-5 shows each of the 19 core creation options and the total amount of habitat created by each option and the proportion of habitat created. Sensitivity classifications adopted in the NBCCVA study and for this study are also listed; the ranges (in the two rightmost columns) reflect the different priority habitat types over which the 19 options are found.

The results suggest that options that support woodland habitat creation make up exactly half (3,842 ha of 7,688 ha) of all uptake whilst uptake on grasslands (22.4% or 1,725 ha) and wetlands (21.9% or 1,232 ha) is around one fifth. Crucially, uptake within coastal habitats (i.e. areas that are at significant risk from the impacts of climate change) is very low (5.3% or 409.6 ha). However, using the data available it is difficult to discern much about the sensitivity of habitats at this level (the resolution of the data is too coarse). In this regard, a more robust approach might be to use higher resolution (e.g. field parcel information from GENESIS) to better understand the relationship between where habitat is created and areas that are most sensitive to climate change.

Table 4-5 Individual selected creation option uptake by broad habitat types and sensitivity

Option	Broad habitat type	Total area (ha) of option uptake within broad priority habitat types within UAA in England	Total area (ha) of habitat created by each option	% of habitat created by each option	Habitat sensitiv-ity from NBCCVA	Habitat sensitivity from this project (1-5, where 1=most sensitive)
HP7 - Creation of inter-tidal and saline habitat on arable land	Coastal	409.6	100.6	1.3%	H-M	1-2
HP8 - Creation of inter-tidal and saline habitat on grassland	Coastal		164.7	2.1%		
HP9 - Creation of inter-tidal and saline habitat by non-intervention	Coastal		135.4	1.8%		
HP3 - Creation of vegetated shingle and sand dune on arable	Coastal		0	0.0%		
HP4 - Creation of vegetated shingle and sand dune on grassland	Coastal		8.8	0.1%		
HK13 - Creation of wet grassland for breeding waders	Grasslands	1,725	998..0	13.0%	H-L	2-5
HK14 - Creation of wet grassland for wintering waders and wildfowl	Grasslands		473.6	6.2%		
HK8 - Creation of species-rich, semi-natural grassland	Grasslands		252.9	3.3%		
HO4 - Creation of lowland heathland from arable or improved grassland	Heath	29.2	29.2	0.4%	M	3
HO5 - Creation of lowland heathland on worked mineral sites	Heath		0.1	0.0%		
HL11 - Creation of upland heathland	Upland	1,232	1,232	16.0%	H-L	1-4
HQ8 - Creation of fen	Wetland	451.1	305.4	4.0%	H-M	1-2
HQ5 - Creation of reedbeds	Wetland		145.7	1.9%		
HC21 - Creation of traditional orchards	Woodland	3,842	233.7	3.0%		
HC17 - Creation of successional areas and scrub	Woodland		1,277	16.6%	H-L	2-5
HC14 - Creation of wood pasture	Woodland		163.7	2.1%		
HC10 - Creation of woodland outside of the SDA & ML	Woodland		43.1	0.6%		
HC9 - Creation of woodland in the SDA	Woodland		39.4	0.5%		
WCG - Woodland Creation Grant	Woodland		2,085	27.1%		
Total			7,688	100%		

B. Reducing fragmentation and enhancing ecological networks

Indicator B1: Creation options will reduce fragmentation

Monitoring question (national-scale): What is the proportion and total area of appropriate creation options in each habitat fragmentation area?

Summary of result: There is little evidence to suggest that areas of high habitat fragmentation are the focus for habitat creation. In addition, there is very little difference in the uptake of habitat creation options between areas that are highly fragmented and those that are less highly fragmented.

For all fragmentation indicators relating to priority habitats (B1 and B5), there is little evidence of geographical bias.

Two categories of 'fragmentation area' (at 1km proximity) are provided for 25 different priority habitat types. The 'top 20%' areas represent areas where fragmented habitat patches occur in clusters that are in close proximity to each other and therefore may provide the greatest potential to enhance fragmented habitat networks. The remaining areas ('bottom 80%') represent fragmented habitat patches that may be more isolated from each other but that may also provide opportunities for reducing fragmentation and increasing habitat patch size. The two 'top 20%' and 'bottom 80%' layers are referenced throughout.

Table 4-6 and Table 4-7 shows the total area of land within the UAA located within each of the fragmentation area layers (these areas depict sites that are highly fragmented and may provide a potential for habitat creation that would enhance the ecological network). They also show the total area of core creation options within each fragmentation area and then the total area of core creation options, within the UAA, within each fragmentation area. Lastly, they show the proportion of the UAA within each fragmentation area covered by core creation options.

The uptake of core creation options are relatively small in the fragmentation areas due to the relatively small areas that they cover when compared to land that is located in the UAA. As a result, uptake is very low (represented by the small % values in the right-most columns of Table 4-6 and Table 4-7). The total area of creation options within each of the fragmentation areas that is located within the UAA are very similar; this is to be expected as creation of habitat should be targeted to land that is located within the UAA (i.e. it is eligible to receive funding via ES). Table E-6 shows the total area of land within the UAA located outside of each of the fragmentation areas; the data here echoes the trend evidenced by Table 4-6 and Table 4-7 (i.e. there are large amounts of land located outside of the fragmentation areas and the amount of core creation is relatively small).

There is very little difference in the uptake of core creation options between areas that are highly fragmented (the 'top 20%' – see Table 4-6) and those that are less highly fragmented (the 'bottom 80%' – see Table 4-7).

Table 4-6 Total area of selected creation options within 'top 20%' of highly fragmented areas for individual priority habitats

Priority habitat	Total area (ha) of land within the UAA within each fragmentation area	Total area (ha) of creation options within each fragmentation area	Total area (ha) of creation options within the UAA, within each fragmentation area	% of the UAA within each fragmentation area covered by creation options
BLB = Blanket bog	162,217	633.7	633.7	0.39%
CGM = Coastal grazing marsh	294,632	1,693.7	1,693.1	0.57%
CSD = Coastal sand dune	8,522	50.3	50.3	0.59%
CVS = Coastal vegetated shingle	4,933	45.3	45.3	0.92%
FGM = Floodplain grazing marsh	487,550	1,973.7	1,973.7	0.40%
LCG = Lowland calcareous grassland	363,516	1,128.5	1,128.5	0.31%
LDA = Lowland dry acid grassland	110,465	43.6	43.6	0.04%
LF = Lowland fens	291,269	553.3	553.3	0.19%
LHT = Lowland heathland	208,123	199.2	199.2	0.10%
LMD = Lowland dry meadows	84,168	72.9	72.9	0.09%
LMW = Lowland meadows (wet)	547,174	637.5	637.5	0.12%
LP = Limestone pavements	23,108	59.6	59.6	0.26%
LRB = Lowland raised bogs	31,397	161.9	161.9	0.52%
MCS = Maritime cliff and slope	24,569	36.9	36.9	0.15%

Priority habitat	Total area (ha) of land within the UAA within each fragmentation area	Total area (ha) of creation options within each fragmentation area	Total area (ha) of creation options within the UAA, within each fragmentation area	% of the UAA within each fragmentation area covered by creation options
MDF = Mudflats	57,955	162.4	162.4	0.28%
MHW = Mountain heath and willow scrub	10,442	0.0	0.0	0.00%
PMG = Purple moor grass and rush pasture	194,990	139.9	139.9	0.07%
RDB = Reedbeds	61,907	221.3	220.8	0.36%
SLG = Saline lagoons	3,324	8.5	8.5	0.26%
SM = Saltmarsh	9,684	43.0	43.0	0.44%
TOR = Orchards	1,029,340	819.6	819.6	0.08%
UCG = Upland calcareous grassland	30,219	33.3	33.3	0.11%
UHM - Upland hay meadows	55,559	0.0	0.0	0.00%
UHT = Upland heathland	83,324	35.8	35.8	0.04%
UFF = Upland fens and flushes	25,366	1.8	1.8	0.01%

Table 4-7 Total area of selected creation options within 'bottom 80%' of highly fragmented areas for individual priority habitats

Priority habitat	Total area (ha) of land within the UAA within each fragmentation area	Total area (ha) of creation options within each fragmentation area	Total area (ha) of creation options within the UAA, within each fragmentation area	% of the UAA within each fragmentation area covered by creation options
BLB = Blanket bog	106,870	885.9	885.9	0.83%
CGM = Coastal grazing marsh	134,858	769.0	769.5	0.57%
CSD = Coastal sand dune	9,645	16.3	15.7	0.16%
CVS = Coastal vegetated shingle	6,684	148.6	148.6	2.22%
FGM = Floodplain grazing marsh	470,474	1,281.8	1,281.2	0.27%
LCG = Lowland calcareous grassland	264,248	521.4	521.3	0.20%
LDA = Lowland dry acid grassland	152,053	90.3	90.3	0.06%
LF = Lowland fens	382,678	799.2	798.6	0.21%
LHT = Lowland heathland	220,016	351.5	351.4	0.16%
LMD = Lowland dry meadows	163,111	179.5	179.5	0.11%
LMW = Lowland meadows (wet)	547,436	755.9	755.8	0.14%
LP = Limestone pavements	21,395	1.5	1.5	0.01%
LRB = Lowland raised bogs	32,976	84.1	84.1	0.25%
MCS = Maritime cliff and slope	29,195	33.4	33.4	0.11%
MDF = Mudflats	48,331	309.5	309.5	0.64%
MHW = Mountain heath and willow scrub	22,322	0	0	0.00%
PMG = Purple moor grass and rush pasture	126,870	137.9	137.9	0.11%
RDB = Reedbeds	96,945	399.3	399.3	0.41%
SLG = Saline lagoons	9,519	11.2	11.2	0.12%
SM = Saltmarsh	20,275	44.5	44.5	0.22%
TOR = Orchards	648,486	730.3	730.3	0.11%
UCG = Upland calcareous grassland	41,365	0	0	0.00%
UHM - Upland hay meadows	66,886	0	0	0.00%
UHT = Upland heathland	147,945	327.3	327.3	0.22%
UFF = Upland fens and flushes	46,684	24.0	24.0	0.05%

Table 4-8 (overleaf) shows the total amount of core creation options that are located within (and outside of) the fragmentation areas. Crucially, there is much less uptake of core creation options found within areas that are highly fragmented. Floodplain grazing marsh has the greatest coverage of fragmented habitat (20.8%). The average uptake of core creation options within the UAA within the fragmentation areas is 4.3% (min:0%, max: 20.8%). Therefore, there is little evidence to suggest that there are more options being implemented on fragmented habitats under ES. Tables E-1, Table E-4 and Table E-5 further reinforce this, highlighting that there is no concentration of creation options within the fragmentation areas.

Table E-7 provides a breakdown of core creation option uptake within each NCA. The Fens (NCA 46) contains the greatest amount of uptake (1,315 ha or 7.7% of all core creation options).

Table 4-8 Total area (ha) of selected core creation inside, and outside of, fragmentation areas

Priority habitat	Total area (ha) of core creation within the UAA within any fragmentation area	Total area (ha) of core creation, within the UAA, outside of any fragmentation area	% of core creation, within the UAA, within fragmentation area	Total area (ha) of core creation
BLB = Blanket bog	1,520	14,101	9.7%	15,621
CGM = Coastal grazing marsh	2,463	13,158	15.8%	15,621
CSD = Coastal sand dune	66	15,554	0.4%	15,621
CVS = Coastal vegetated shingle	194	15,427	1.2%	15,621
FGM = Floodplain grazing marsh	3,255	12,365	20.8%	15,621
LCG = Lowland calcareous grassland	1,650	13,971	10.6%	15,621
LDA = Lowland dry acid grassland	134	15,487	0.9%	15,621
LF = Lowland fens	1,352	14,268	8.7%	15,621
LHT = Lowland heathland	551	15,070	3.5%	15,621
LMD = Lowland dry meadows	252	15,368	1.6%	15,621
LMW = Lowland meadows (wet)	1,393	14,227	8.9%	15,621
LP = Limestone pavements	61	15,560	0.4%	15,621
LRB = Lowland raised bogs	246	15,375	1.6%	15,621
MCS = Maritime cliff and slope	70	15,550	0.5%	15,621
MDF = Mudflats	472	15,149	3.0%	15,621
MHW = Mountain heath and willow scrub	-	15,621	0.0%	15,621
PMG = Purple moor grass and rush pasture	278	15,343	1.8%	15,621
RDB = Reedbeds	620	15,000	4.0%	15,621
SLG = Saline lagoons	20	15,601	0.1%	15,621
SM = Saltmarsh	87	15,533	0.6%	15,621
TOR = Orchards	1,550	14,071	9.9%	15,621
UCG = Upland calcareous grassland	33	15,587	0.2%	15,621
UHM – Upland hay meadows	-	15,621	0.0%	15,621
UHT = Upland heathland	363	15,258	2.3%	15,621
UFF = Upland fens and flushes	26	15,595	0.2%	15,621

Note: the total area of core creation (rightmost column) is the same as the analysis here looks at the breakdown of the total amount of core creation within, and outside of, each fragmentation area.

Indicator B2: Restoration options will support the reduction of fragmentation

Monitoring question (national-scale): What is the proportion and total area of appropriate restoration options in each fragmentation area?

Summary of result: There is little evidence to suggest that highly fragmented areas are the focus for habitat restoration. In addition, there is very little difference in the uptake of restoration options between areas that are highly fragmented and those that are less highly fragmented. However, there is greater uptake of restoration options than that of creation (indicator B5). For all fragmentation outcomes of priority habitats (B2 and B5), there is little evidence of geographical targeting.

Table 4-9 and Table 4-10 (overleaf) shows the total area of land within the UAA located within each of the fragmentation area layers (these areas depict sites that are highly fragmented and may provide a potential for habitat creation that would enhance the ecological network). They also show the total area of restoration options within each fragmentation area and then the total area of restoration options, within the UAA, within each fragmentation area. Lastly, they show the proportion of the UAA within each fragmentation area covered by restoration options.

The uptake of restoration options within highly fragmented areas is generally greater than that of core creation options (see Section 4, indicator B1), this may possibly be due to the larger land areas over which restoration options are applied. The total area of restoration options within each fragmentation area that is located within the UAA are very similar; this is to be expected as the restoration of habitat should be targeted to land that is located within the UAA (i.e. it is eligible to receive funding via ES). Table E-10 shows the total area of land within the UAA located outside of each of the fragmentation areas; the data here echoes the trend evidenced by Table 4-9 and Table 4-10 although to a lesser degree than for creation options (i.e. there are large amounts of land located outside of the fragmentation areas and the amount of core creation is relatively small – see Section 4, indicator B1).

There is slightly more uptake (~2.6%, min=4.6%, max=29.2%) of restoration options within the Top 20% fragmented areas (areas with the most clustered patches of fragmented habitat) than there is in the ‘Bottom

80%' (areas with less clustering of fragmented habitat); this suggests that there is generally more restoration within the most highly clustered fragmented areas.

There is evidence of different amounts of uptake across the individual habitat types where some habitats appear to be more favoured than others. For example, blanket bog (39%/31%), upland fens and flushes (55%/25%) and mountain heathland (60%/64%) all appear to have a greater coverage of restoration options in both the most highly clustered fragmented areas ('top 20%') and less clustered fragmented ('bottom 80%') areas than across all national UAA. However, this inter-habitat variability may simply reflect the relative abundance and/or ease of targeting these particular habitats through agri-environment schemes. Moreover, uptake of restoration options within highly clustered fragmented areas may also simply reflect the relative (poorer) condition of these habitats.

Table 4-9 Total area of selected core restoration options within 'top 20%' of highly fragmented sites for individual priority habitats

Priority habitat	Total area (ha) of land within the UAA within each fragmentation area	Total area (ha) of restoration options within each fragmentation area	Total area (ha) of restoration options within the UAA, within each fragmentation area	% of the UAA within each fragmentation area covered by restoration options
BLB = Blanket bog	162,217	63,522	63,333	39%
CGM = Coastal grazing marsh	294,632	2,308	2,302	1%
CSD = Coastal sand dune	8,522	275	275	3%
CVS = Coastal vegetated shingle	4,933	102	102	2%
FGM = Floodplain grazing marsh	487,550	8,468	8,468	2%
LCG = Lowland calcareous grassland	363,516	18,085	18,071	5%
LDA = Lowland dry acid grassland	110,465	11,589	11,546	10%
LF = Lowland fens	291,269	29,110	29,110	10%
LHT = Lowland heathland	208,123	41,959	41,604	20%
LMD = Lowland dry meadows	84,168	3,232	3,232	4%
LMW = Lowland meadows (wet)	547,174	18,124	18,122	3%
LP = Limestone pavements	23,108	7,597	7,452	32%
LRB = Lowland raised bogs	31,397	1,612	1,612	5%
MCS = Maritime cliff and slope	24,569	1,591	1,591	6%
MDF = Mudflats	57,955	533	533	1%
MHW = Mountain heath and willow scrub	10,442	6,253	6,253	60%
PMG = Purple moor grass and rush pasture	194,990	13,095	13,066	7%
RDB = Reedbeds	61,907	2,827	2,827	5%
SLG = Saline lagoons	3,324	44	44	1%
SM = Saltmarsh	9,684	194	194	2%
TOR = Orchards	1,029,340	11,814	11,810	1%
UCG = Upland calcareous grassland	30,219	11,525	11,525	38%
UHM - Upland hay meadows	55,559	6,147	6,147	11%
UHT = Upland heathland	83,324	14,817	14,817	18%
UFF = Upland fens and flushes	25,366	13,855	13,855	55%

Table 4-10 Total area of selected core restoration options within 'bottom 80%' of highly fragmented sites for individual priority habitats

Priority habitat	Total area (ha) of land within the UAA within each fragmentation area	Total area (ha) of restoration options within each fragmentation area	Total area (ha) of restoration options within the UAA, within each fragmentation area	% of the UAA within each fragmentation area covered by restoration options
BLB = Blanket bog	106,870	32,919	32,919	31%
CGM = Coastal grazing marsh	134,858	1,717	1,717	1%
CSD = Coastal sand dune	9,645	718	718	7%
CVS = Coastal vegetated shingle	6,684	370	370	6%
FGM = Floodplain grazing marsh	470,474	5,456	5,447	1%
LCG = Lowland calcareous grassland	264,248	11,687	11,687	4%
LDA = Lowland dry acid grassland	152,053	11,818	11,817	8%
LF = Lowland fens	382,678	24,184	24,141	6%
LHT = Lowland heathland	220,016	31,227	31,222	14%
LMD = Lowland dry meadows	163,111	4,734	4,734	3%
LMW = Lowland meadows (wet)	547,436	15,916	15,900	3%

Priority habitat	Total area (ha) of land within the UAA within each fragmentation area	Total area (ha) of restoration options within each fragmentation area	Total area (ha) of restoration options within the UAA, within each fragmentation area	% of the UAA within each fragmentation area covered by restoration options
LP = Limestone pavements	21,395	4,206	4,206	20%
LRB = Lowland raised bogs	32,976	822	822	2%
MCS = Maritime cliff and slope	29,195	2,315	2,305	8%
MDF = Mudflats	48,331	654	654	1%
MHW = Mountain heath and willow scrub	22,322	14,383	14,383	64%
PMG = Purple moor grass and rush pasture	126,870	6,119	6,118	5%
RDB = Reedbeds	96,945	1,474	1,461	2%
SLG = Saline lagoons	9,519	210	210	2%
SM = Saltmarsh	20,275	449	449	2%
TOR = Orchards	648,486	7,586	7,632	1%
UCG = Upland calcareous grassland	41,365	9,877	9,877	24%
UHM - Upland hay meadows	66,886	9,734	9,691	14%
UHT = Upland heathland	147,945	26,960	26,917	18%
UFF = Upland fens and flushes	46,684	11,855	11,855	25%

Table 4-11 below shows the total amount of restoration options that are located within (and outside of) the fragmentation areas. Blanket bog (17.7%) and lowland heathland (13.4%) are the priority habitats with the greatest coverage of restoration options within the most highly fragmented areas. There is limited evidence to suggest that the most highly clustered fragmented areas are the focus of agri-environment schemes, this is also evidenced by Table E-8 and Table E-9.

Table 4-11 Total area (ha) of selected core restoration options inside, and outside of, fragmentation areas

Priority habitat	Total area (ha) of core restoration within the UAA within any fragmentation area	Total area (ha) of core restoration, within the UAA, outside of any fragmentation area	% of core restoration, within the UAA, within fragmentation area	Total area (ha) of core restoration
BLB = Blanket bog	96,252	446,921	17.7%	543,173
CGM = Coastal grazing marsh	4,020	539,154	0.7%	543,173
CSD = Coastal sand dune	993	542,181	0.2%	543,173
CVS = Coastal vegetated shingle	472	542,701	0.1%	543,173
FGM = Floodplain grazing marsh	13,915	529,258	2.6%	543,173
LCG = Lowland calcareous grassland	29,757	513,416	5.5%	543,173
LDA = Lowland dry acid grassland	23,363	519,810	4.3%	543,173
LF = Lowland fens	53,251	489,922	9.8%	543,173
LHT = Lowland heathland	72,826	470,347	13.4%	543,173
LMD = Lowland dry meadows	7,966	535,207	1.5%	543,173
LMW = Lowland meadows (wet)	34,021	509,152	6.3%	543,173
LP = Limestone pavements	11,658	531,516	2.1%	543,173
LRB = Lowland raised bogs	2,434	540,739	0.4%	543,173
MCS = Maritime cliff and slope	3,896	539,277	0.7%	543,173
MDF = Mudflats	1,187	541,986	0.2%	543,173
MHW = Mountain heath and willow scrub	20,636	522,537	3.8%	543,173
PMG = Purple moor grass and rush pasture	19,185	523,988	3.5%	543,173
RDB = Reedbeds	4,288	538,885	0.8%	543,173
SLG = Saline lagoons	254	542,919	0.0%	543,173
SM = Saltmarsh	642	542,531	0.1%	543,173
TOR = Orchards	19,443	523,730	3.6%	543,173
UCG = Upland calcareous grassland	21,402	521,771	3.9%	543,173
UHM – Upland hay meadows	15,837	527,336	2.9%	543,173
UHT = Upland heathland	41,734	501,439	7.7%	543,173
UFF = Upland fens and flushes	25,710	517,463	4.7%	543,173

Note: the total area of core restoration (rightmost column) is the same as the analysis here looks at the breakdown of the total amount of core restoration within, and outside of, each fragmentation area.

Indicator B5: Matrix options to restore or create features should be focused in areas of high fragmentation

Monitoring question (national-scale): What is the proportion and total area of appropriate creation and restoration matrix options in each fragmentation area?

Summary of result: There is little evidence to suggest that highly fragmented areas are the focus of ES. For all fragmentation outcomes of priority habitats (B2 and B5), there is little evidence of geographical bias.

Table 4-12 and Table 4-13 overleaf show the uptake of selected creation and restoration options, within (and outside of) the UAA, located within each of the fragmentation area layers (these areas depict sites that are highly fragmented and may provide a potential for habitat creation that would enhance the ecological network). For this particular analysis, the fragmentation areas (presented earlier in Section 2.1.1.2) were merged into two separate layers; one representing the most highly clustered fragmented sites ('top 20%') and the other representing those areas that are less clustered fragmented areas ('bottom 80%'). Merging the layers in this way recognises the fact that options that support the matrix will occur between habitat patches and support wider improvements in connectivity (i.e. not necessarily linked to particular habitat types).

Most notably, a greater amount of land (~4.3 million ha), within the UAA, is located within the most highly clustered fragmented areas ('top 20%') than in areas that are less highly clustered but still fragmented (~2.6 million ha) (see Table 4-12 and Table 4-13).

Figure 4-6 depicts the likely cause of this; by their very nature, there are large numbers of 'top 20%' clustered fragmented areas that are located in close proximity to one another meaning that they cluster and create much larger zones despite being fewer in number than the less highly clustered fragmented ('bottom 80%') sites. Table 4-12 and Table 4-13 also suggest that there is slightly more (i.e. a greater total area) uptake of creation and restoration options within the most highly fragmented areas than those which are less highly fragmented.

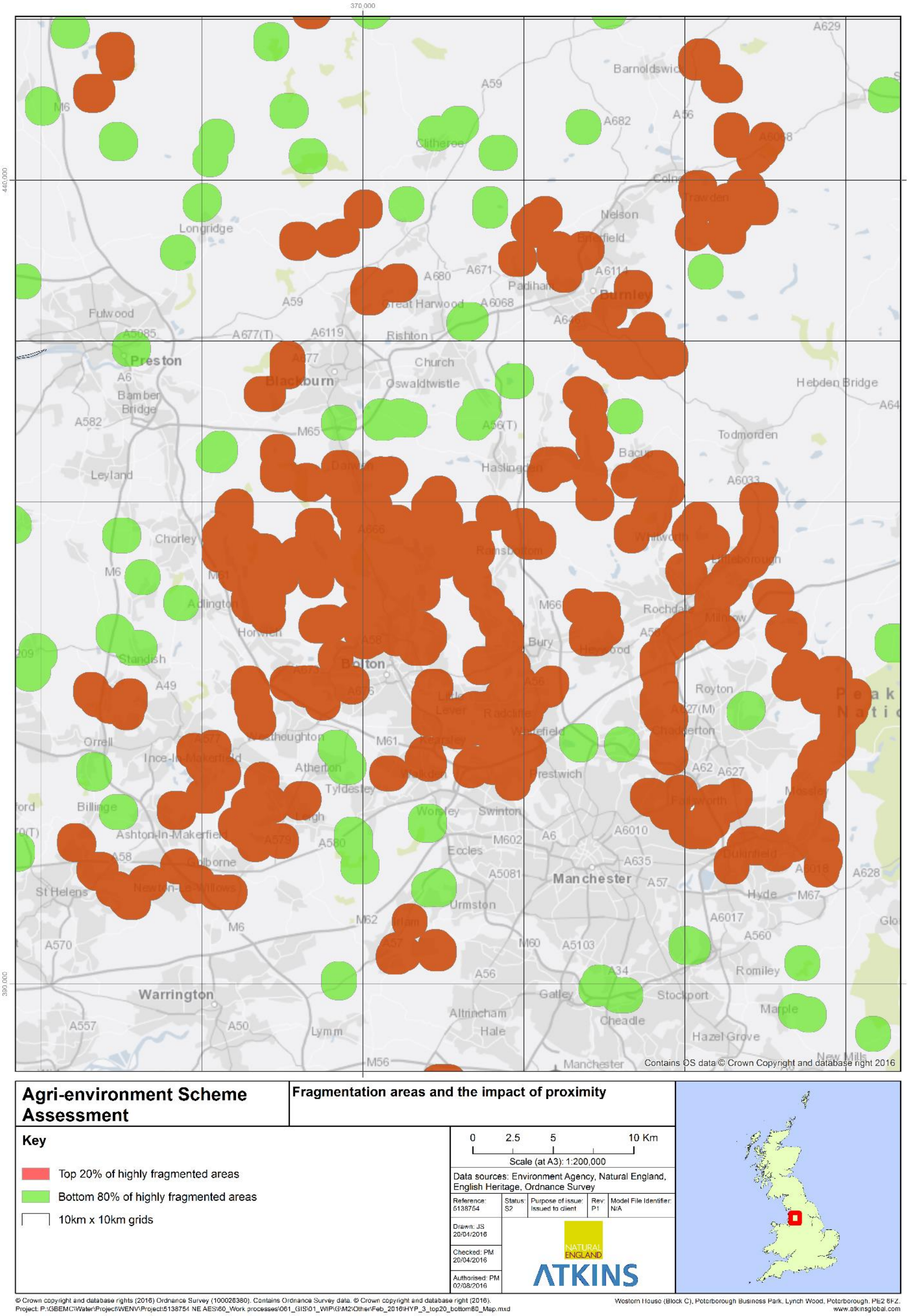
Table 4-12 Total area of selected creation and restoration options within 'top 20%' of highly fragmented sites for all priority habitats

Priority habitat	Total area (ha) of land within the UAA within each fragmentation area	Total area (ha) of creation and restoration options within each fragmentation area	Total area (ha) of creation and restoration options within the UAA, within each fragmentation area	% of the UAA within each fragmentation area covered by creation and restoration options
All priority habitats	4,320,861	130,174	129,912	3.01%

Table 4-13 Total area of selected creation and restoration options within 'bottom 80%' of highly fragmented sites for all priority habitats

Priority habitat	Total area (ha) of land within the UAA within each fragmentation area	Total area (ha) of creation and restoration options within each fragmentation area	Total area (ha) of creation and restoration options within the UAA, within each fragmentation area	% of the UAA within each fragmentation area covered by creation and restoration options
All priority habitats	2,602,999	126,388	126,202	4.85%

Figure 4-6 Fragmentation areas and the impact of proximity



Indicator B7: Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species

Monitoring question (national-scale): What is the proportion of appropriate woodland creation options that fall within 1km of woodland habitat networks?

Summary of result: It is difficult to determine the pattern of uptake of woodland creation within (or close to) woodland habitat networks due to the relative abundance of woodland habitat and the associated search radius of 1 km. It is recommended that a better measure would be to identify the best sites for woodland creation and the proximity (abutting, <0.5 km, <1 km and >1 km) of woodland creation options from these sites.

Figure 4-7 shows the proportion of each 10 km x 10 km grid covered by woodland habitat networks. The woodland habitat networks are available as polygons so their precise location is identifiable on the ground unlike the agri-environment scheme data which is represented as points (centroids to the agreement holding).

The habitat networks themselves occupy large areas and this is reflected in the high proportional coverages within 10 km x 10 km grids as depicted in Figure 4-7. Proportions are greatest in the south and south west regions of England which largely reflects the abundance of woodland habitat.

Figure 4-8 shows the proportion of Woodland Creation Grants (from the EWGS) that fall within 1 km of the woodland habitat networks. Despite the large area covered by woodland habitat networks, the total amount of woodland creation is significantly lower in comparison which results in low proportional coverage when viewed at the 10 km x 10 km grid scale. Coverage therefore appears to be greatest where there is comparatively less woodland habitat networks (i.e. in the north and coastal areas of England). Due to the near-blanket coverage of woodland habitat networks in large parts of the country, and the associated search radius of 1 km, it is difficult to determine with a sufficient level of confidence the pattern(s) of uptake that are evident.

Figure 4-7 Proportion of woodland habitat networks within each 10 km x 10 km grid

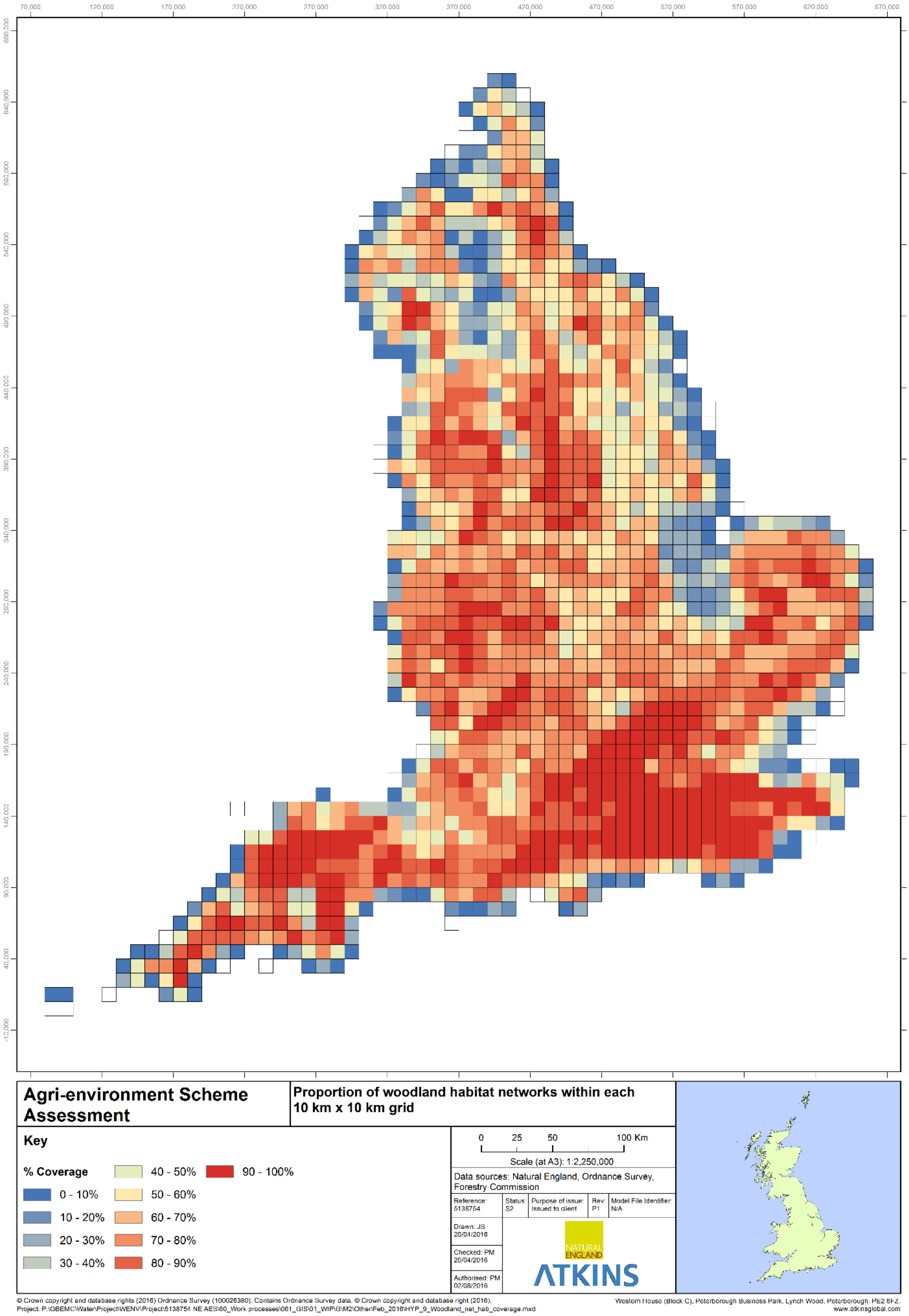
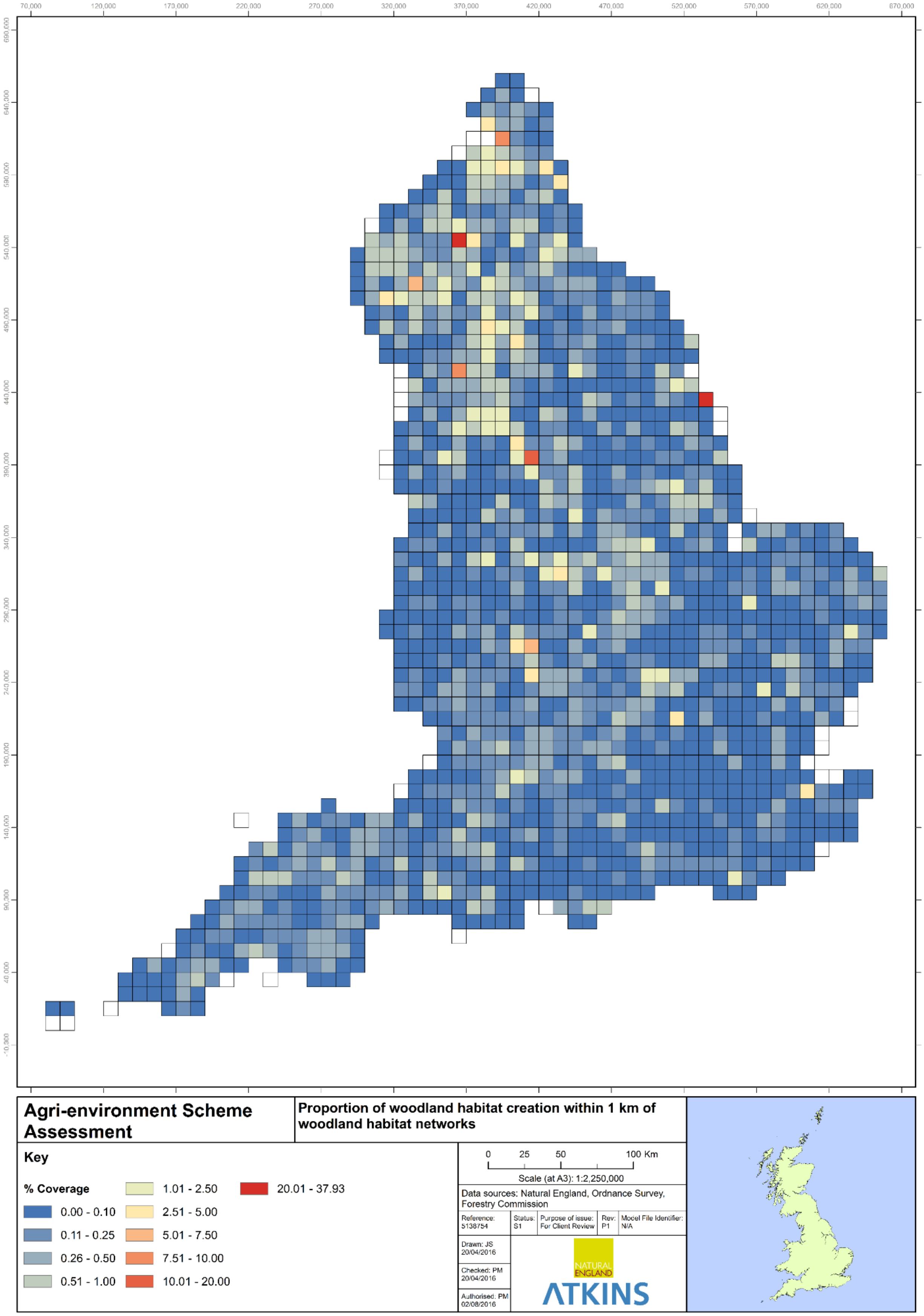


Figure 4-8 Proportion of woodland habitat creation within 1 km of woodland habitat networks



Project: P:\GBEMC\Water\Project\WENV\Project\5138754 NE AES\60_Work processes\061_GIS\01_WIP\G\M2\Other\Feb_2016\HYP_9_Woodland_hab_coverage.mxd

Western House (Block C), Peterborough Business Park, Lynch Wood, Peterborough, PE2 6FZ
www.atkinsglobal.com

C. Protecting refugia

Indicator C1: Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia

Monitoring question (national-scale): What is the area of appropriate creation, maintenance or restoration options in areas of high and low refugia?

Summary of result: Habitat creation appears to favour (i.e. there is a greater concentration) areas with high refugia potential. There is also greater uptake of maintenance and restoration of habitats within areas of high refugia potential than within areas with low refugia potential. Notably, there is no specific targeting of ES schemes to areas of high refugia potential so the relationship is coincidental.

Figure 4-9 overleaf shows refugia potential scores for all taxa across England from Suggitt *et al.,* (2014). Scores closer to 1 indicate grids that have high refugia potential whereas scores closer to 0 indicate low refugia potential for all taxa. The data includes the effects of microclimate. There are 1,509 10km x 10km grids in England. Figure 4-10 (overleaf) shows the top (high refugia potential) and Figure 4-11 (overleaf) shows the bottom (low refugia potential) 10% of 10km x 10km grids by their ranked species refugia score.

To identify areas of high and low refugia potential, firstly each of the 10km x 10km grids were sorted in descending order by their refugia potential score and grids without a score were omitted, leaving 1419 grids. Next, a rank was assigned to the remaining 1,419 grids where 1=high refugium potential (for all taxa) and 1419=low refugium potential (for all taxa). The top 10% (ranks 1 to 142) and bottom (ranks 1277 to 1419) were then able to be identified.

Figure 4-9 Refugia potential scores for all taxa in 10 km x 10 km grids in England

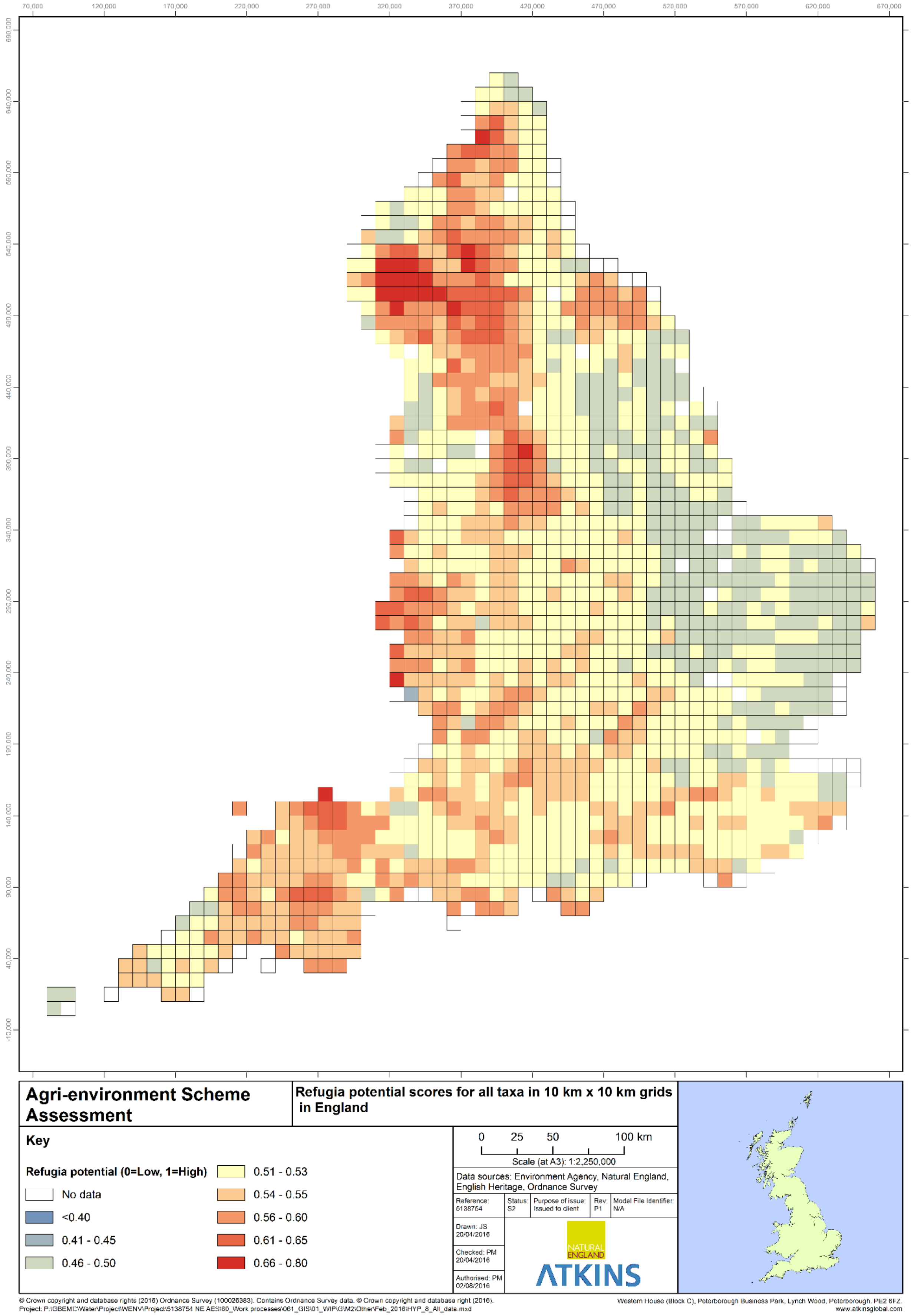
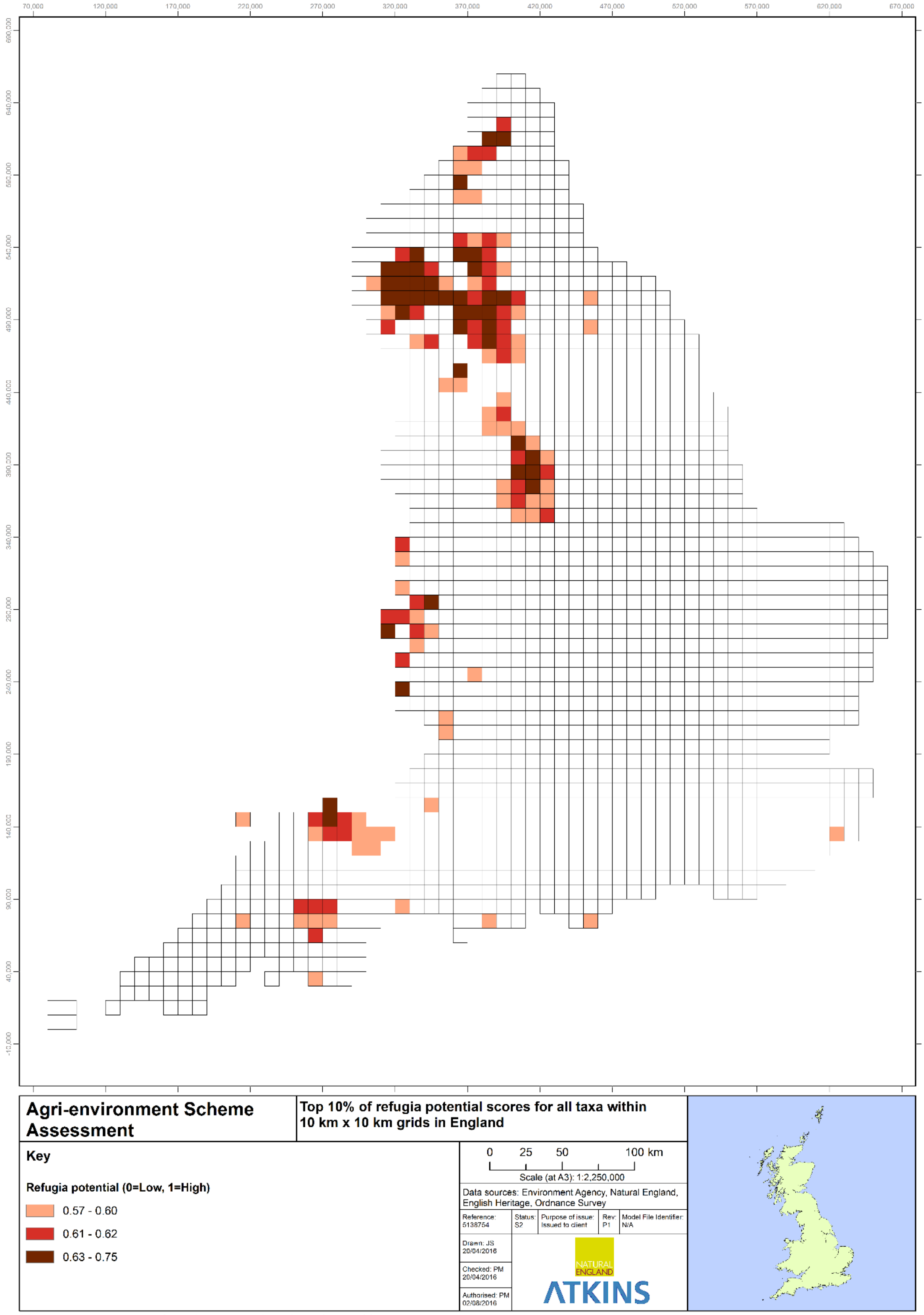


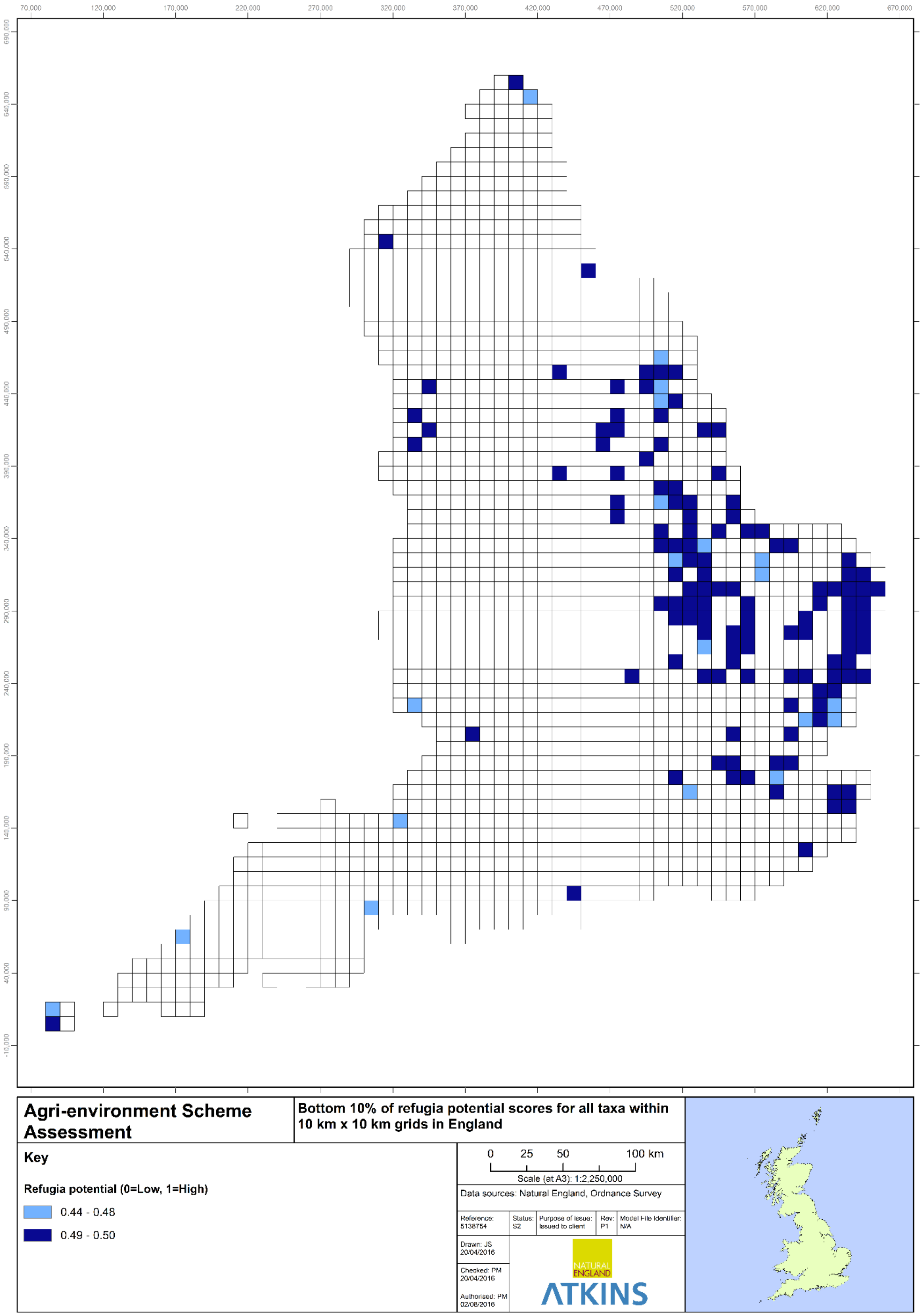
Figure 4-10 Top 10% of refugia potential scores for all taxa within 10 km x 10 km grids in England



Project: P:\GBEMC\Water\Project\WENV\Project\5138754 NE AES\60_Work processes\061_GIS\01_WIP\G\M2\Other\Feb_2016\HYP_8_Top_10.mxd

Western House (Block C), Peterborough Business Park, Lynch Wood, Peterborough. PE2 6FZ.
www.atkinsglobal.com

Figure 4-11 Bottom 10% of refugia potential scores for all taxa within 10 km x 10 km grids in England



Project: P:\GBEMC\Water\Project\WENV\Project\5138754 NE AES\60_Work processes\061_GIS\01_WIP\G\M2\Other\Feb_2016\HYP_8_Bottom_10.mxd

Western House (Block C), Peterborough Business Park, Lynch Wood, Peterborough, PE2 6FZ.
www.atkinsglobal.com

Figure 4-12 shows the ranked refugium potential score (for all taxa) for all 1419 10 km x 10 km grids against the total area (in hectares) of priority habitat within each 10 km x 10 km grid. The figure suggests that grids with higher refugia potential (i.e. ranks closer to 1) generally contain greater areas of priority habitat whilst those with lower ranks contain less priority habitat. However, there are clearly many instances where the reverse is also true.

Figure 4-12 Total area (ha) of priority habitat within areas of high and low species refugia

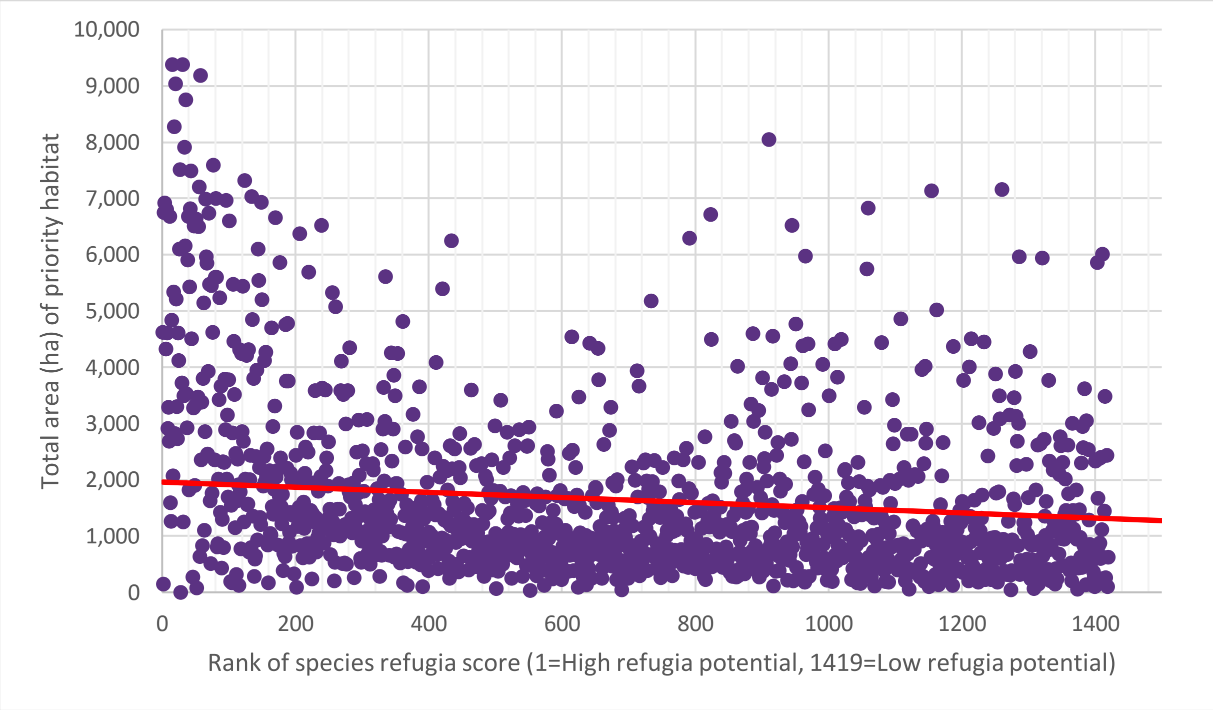


Figure 4-13 shows the same ranked refugium potential scores (for all taxa) for all 1,419 10 km x 10 km grids expressed against the total area (in hectares) of core creation options. The graph suggests that the grids with the highest areas of habitat creation are concentrated towards the higher refugia potential scores, although there are instances where grids with low refugia potential also contain relatively large areas of habitat creation. There is no specific targeting of areas with high refugia potential by agri-environment schemes so the relationship is coincidental.

Figure 4-13 Total area (ha) of selected core creation options within areas of high and low potential to provide refugia for species

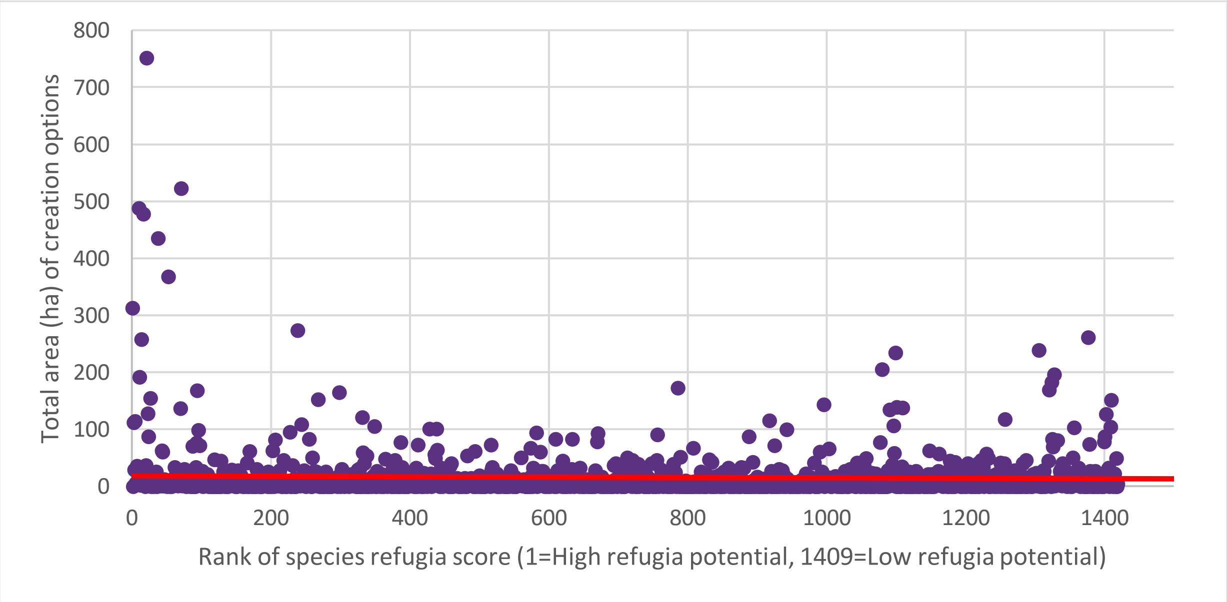
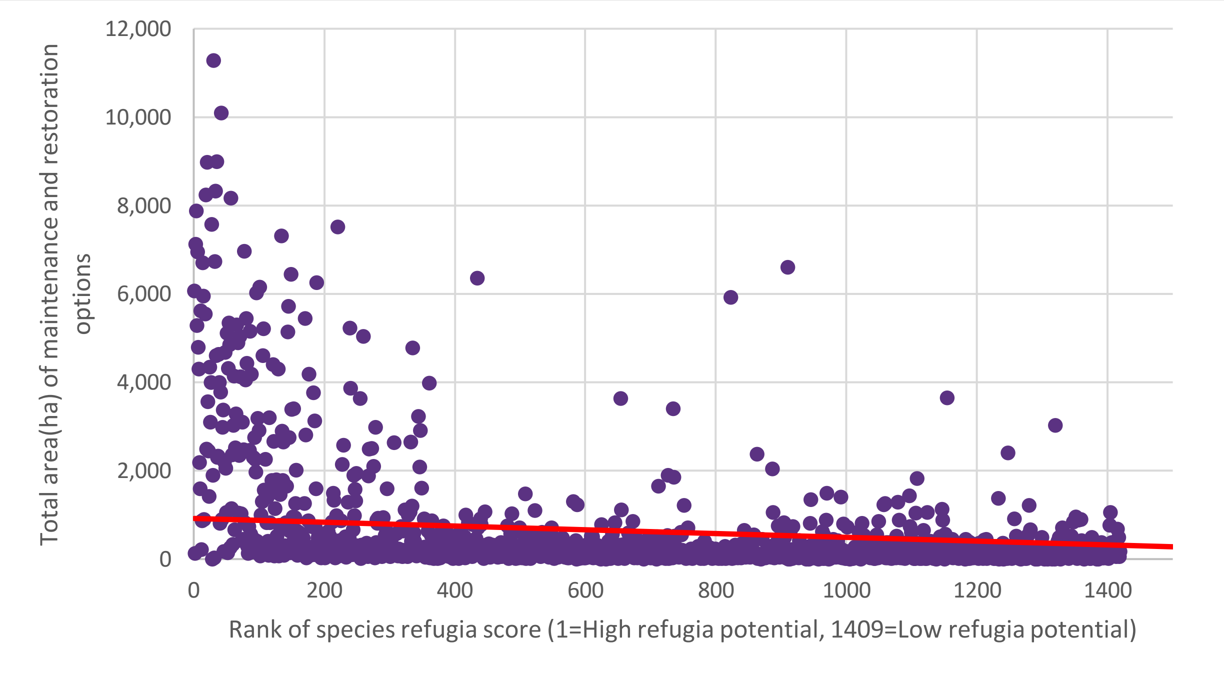


Figure 4-14 shows the same ranked refugium potential scores (for all taxa) for all 1419 10 km x 10 km grids expressed against the total area (in hectares) of maintenance and restoration options. The graph suggests a trend towards grids with high refugia potential scores containing greater uptake of maintenance and restoration options, although as with the creation options, there are a few instances where grids with low refugia potential contain large areas of maintenance and restoration options. This suggests that agri-environment delivery is currently focussed towards areas that have higher refugia potential, despite the absence of any specific targeting to do so.

Figure 4-14 Total area (ha) of selected maintenance and restoration options within areas of high and low species refugia



D. Planning for potential changes in ranges and assemblages of species

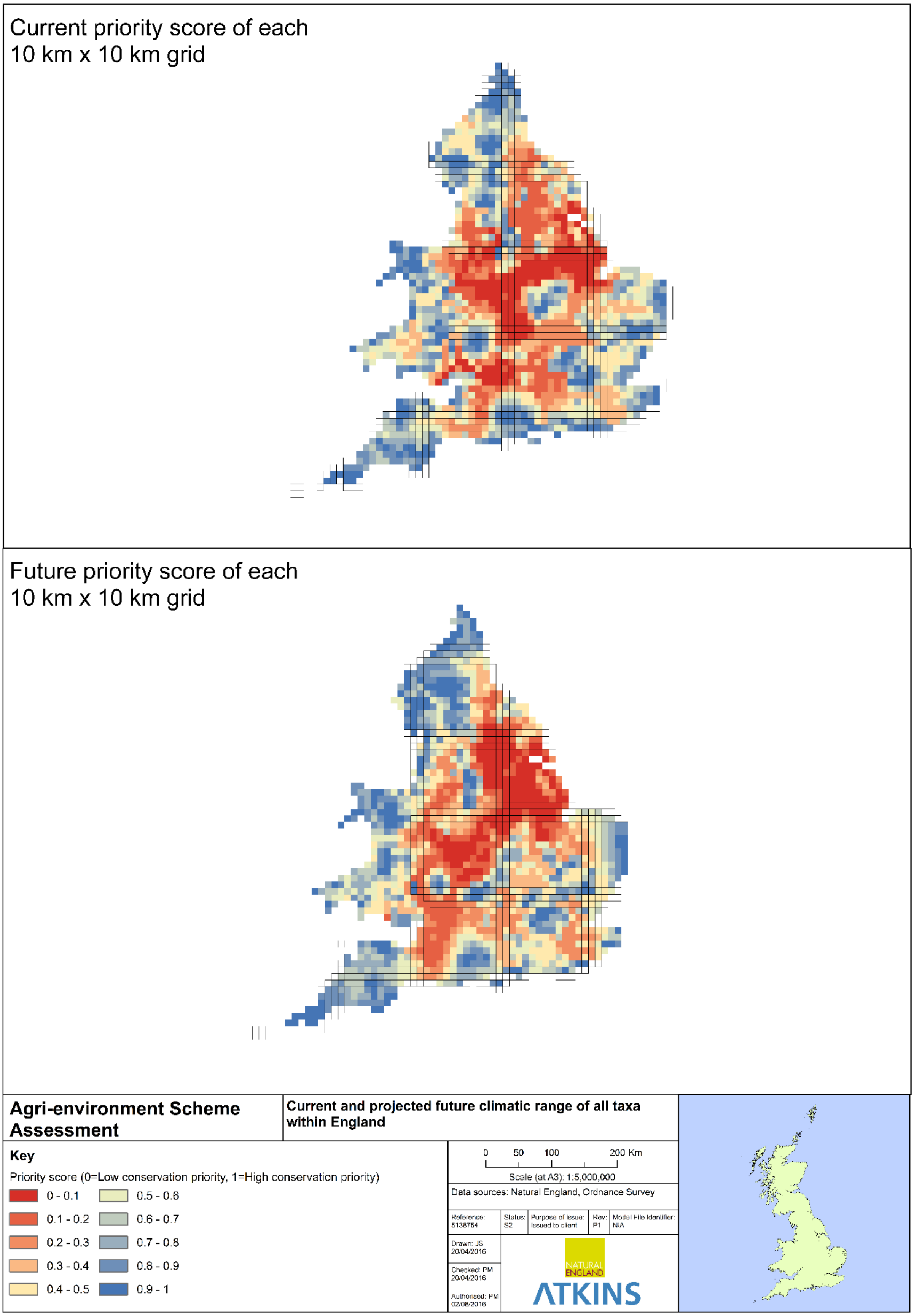
Indicator D1: Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions

Monitoring question (national-scale): What is the total area of appropriate options in relation to the priority areas of future ranges of taxa?

Summary of result: The current distribution highlights that creation and restoration/maintenance options tend to be located in the upper 50% of grids. There does not appear to be any particular focus of major agri-environment scheme activity towards the really high priority (e.g. top 10%, 20%) grids.

Figure 4-15 shows the priority areas for current and future ranges of all taxa across England, based on the modelled distribution of over 3,000 species. There are 1,509 grids in England, many of which are not coincident with these current and future ranges (hence the maximum values of the X-axis not reaching this figure in the graphs that follow).

Figure 4-15 Current and projected future climatic range of all taxa within England



Project: P:\GBEMC\Water\Project\WENV\Project\5138754 NE AES\60_Work processes\061_GIS\01_WIP\GM2\Other\Feb_2016\HYP_10_Priority_Range_Curmet and Future.mxd

Western House (Block C), Peterborough Business Park, Lynch Wood, Peterborough, PE2 6FZ.
www.atkinsglobal.com

Figure 4-16 Total area (ha) of selected creation options within ranks of priority ranges for all taxa. Note: green=top 10%, yellow=bottom10%.

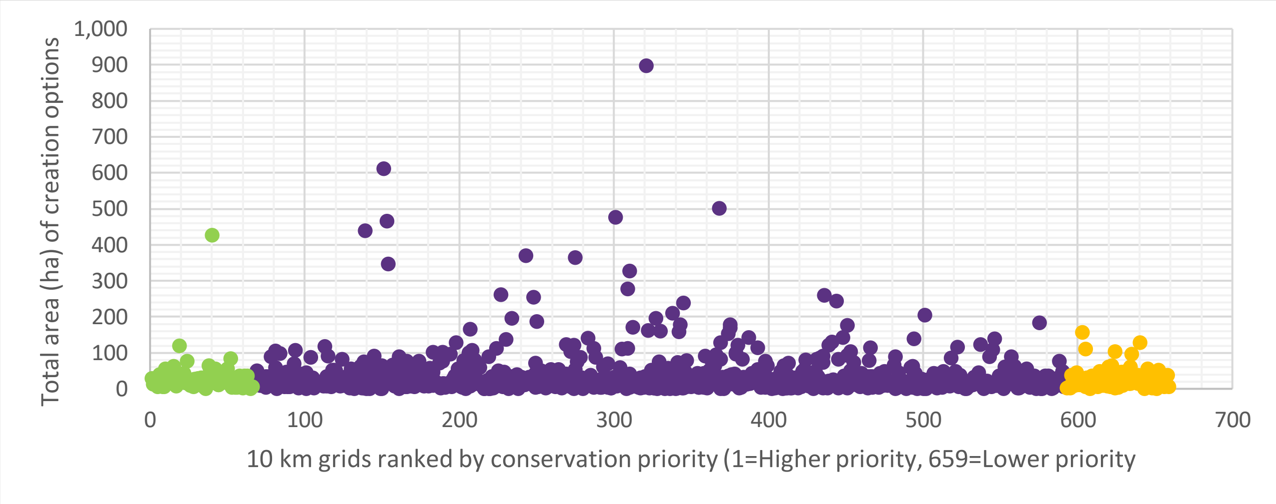


Figure 4-17 Total area (ha) of selected maintenance and restoration options within ranks of priority ranges for all taxa. Note: green=top 10%, yellow=bottom10%.

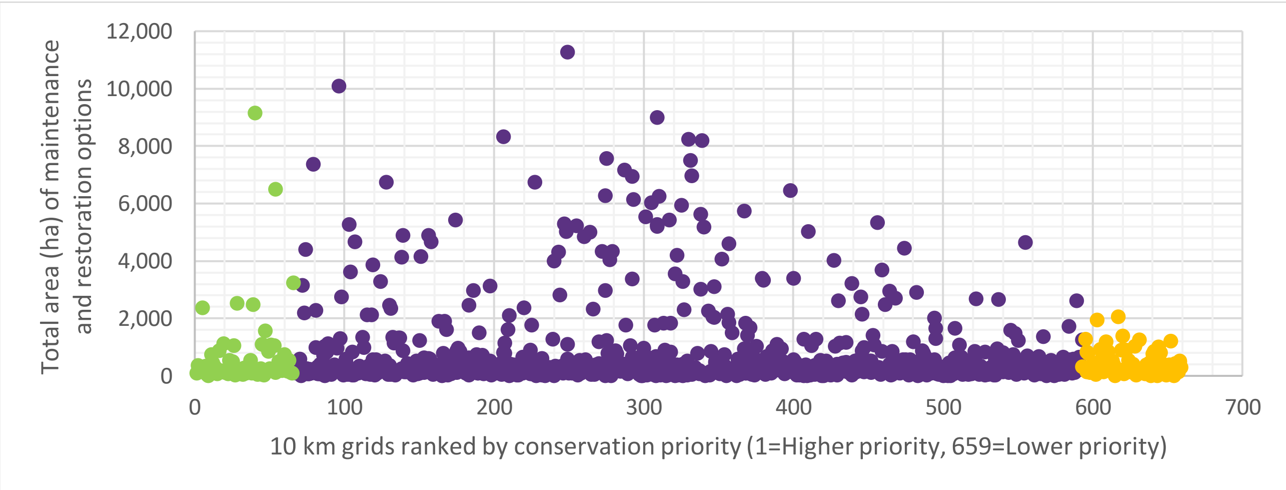


Figure 4-16 and Figure 4-17 above show a similar pattern. The 10 km squares with the greatest area of both creation and restoration/maintenance options tend to be within the top 50% of the ranked grids, suggesting that current action is appropriately placed in relation to the future priority of 10 km squares. However, there is no evidence of the greatest intervention in those cells falling within the top 10 % or 20% of ranked grids.

Indicator D2: Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations

Monitoring question (national-scale): What is the total area of all matrix options in areas of projected high or low species turnover?

Summary of result: There is no clear relationship between the uptake of creation and restoration options that support the matrix and areas of high or low species turnover.

Figure 4-18 (overleaf) shows species turnover across England (see Committee on Climate Change, 2015). Scores closer to 1 indicate grids that have high species turnover whereas scores closer to 0 indicate low species turnover. There are 1,509 10 km x 10 km grids in England.

Figure 4-19 also shows the top 10 % (high species turnover) whilst Figure 4-20 shows the bottom (low species turnover) 10% of 10 km x 10 km grids by their ranked species turnover score. To identify areas of high and low species turnover, firstly each of the 10 km x 10 km grids were sorted in descending order by their species turnover score and grids without a score were omitted, leaving 982 grids. Next, a rank was assigned to the remaining 982 grids where 1=high species turnover and 982=low species turnover. The top 10% (ranks 1 to 92) and bottom (ranks 884 to 982) grids were then able to be identified.

Figure 4-18 Species turnover potential for all taxa within 10 km x 10 km grids in England

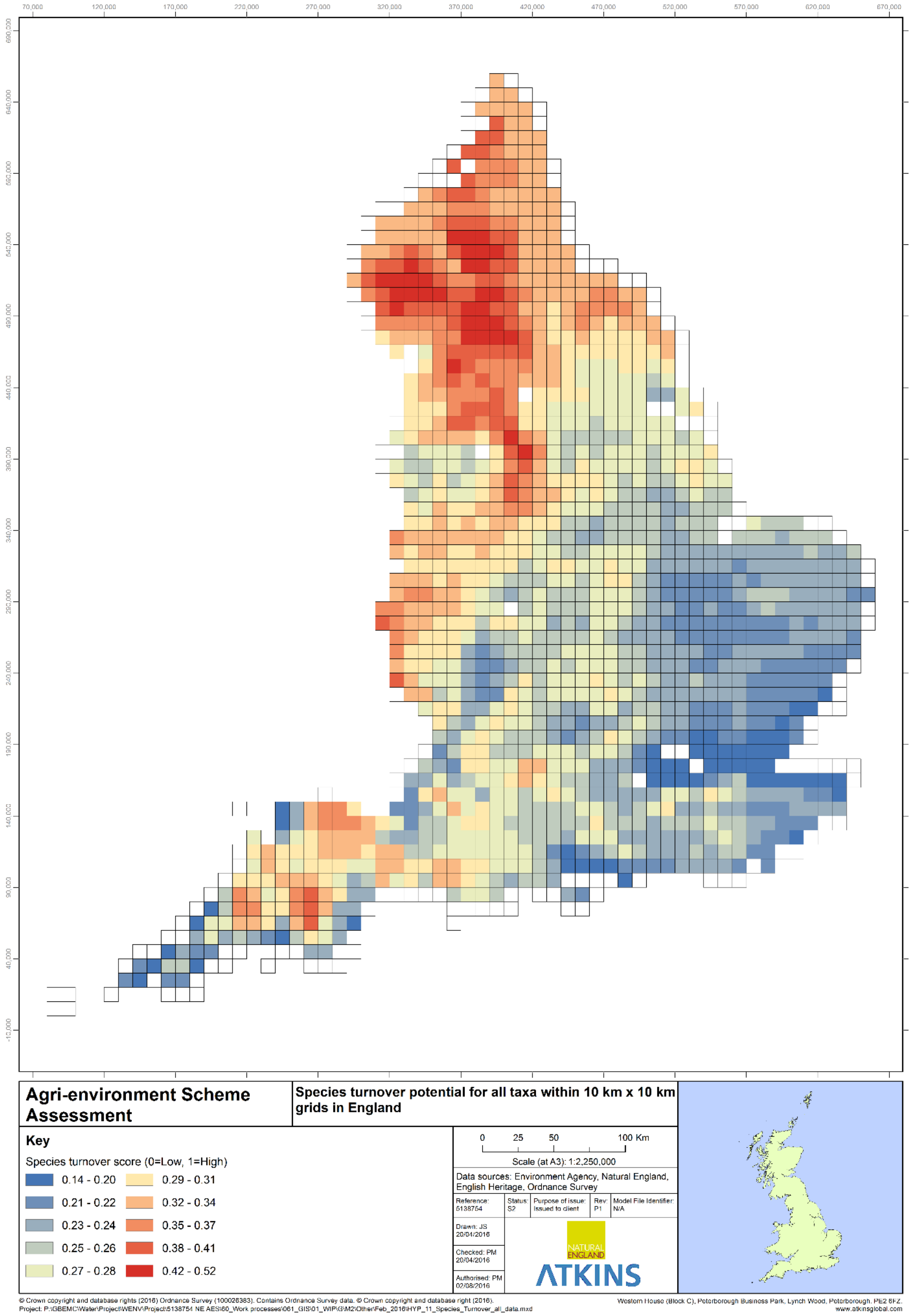


Figure 4-19 Top 10% of areas with high species turnover potential for all taxa within 10 km x 10 km grids in England

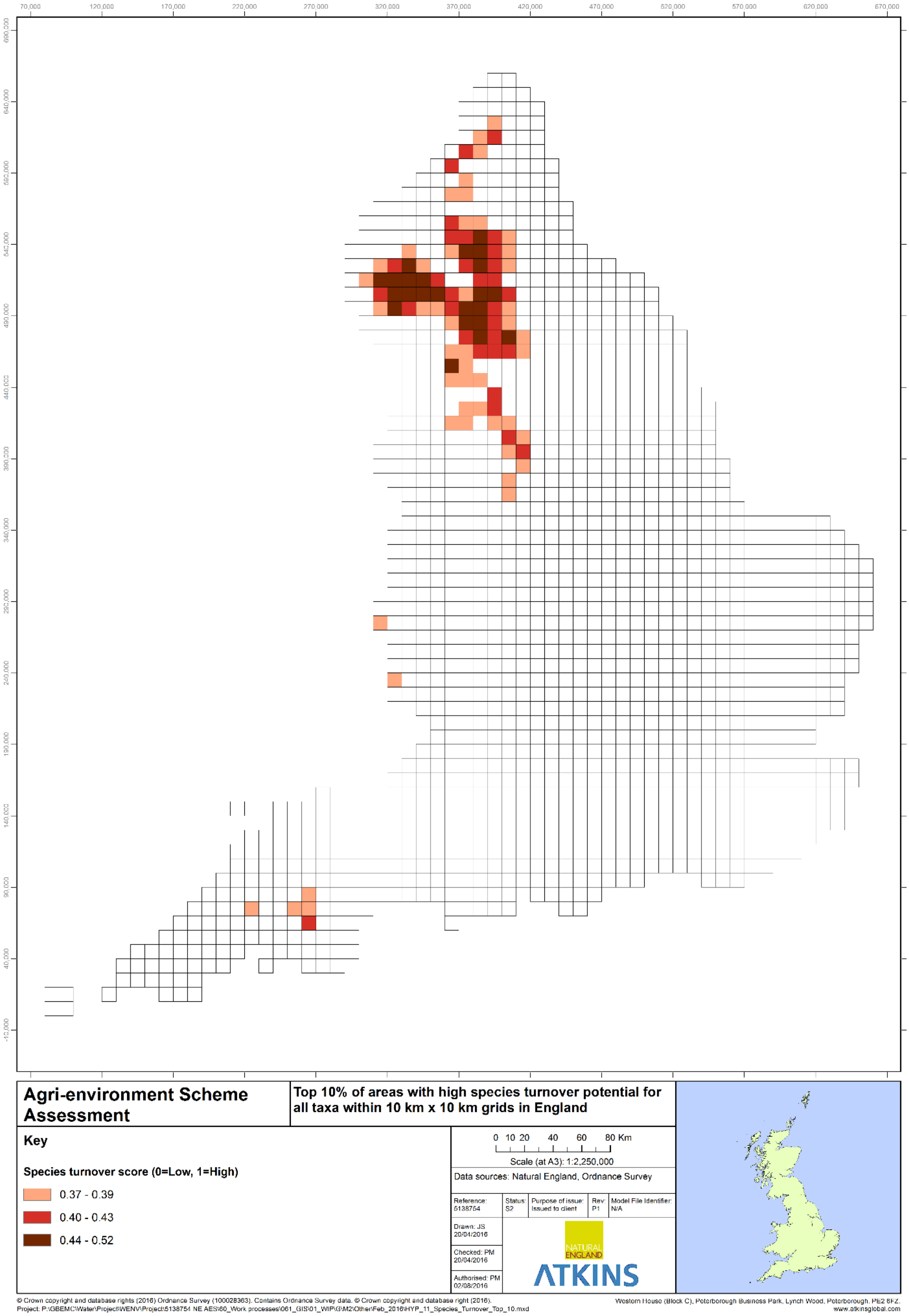


Figure 4-20 Bottom 10% of areas with high species turnover potential for all taxa within 10 km x 10 km grids in England

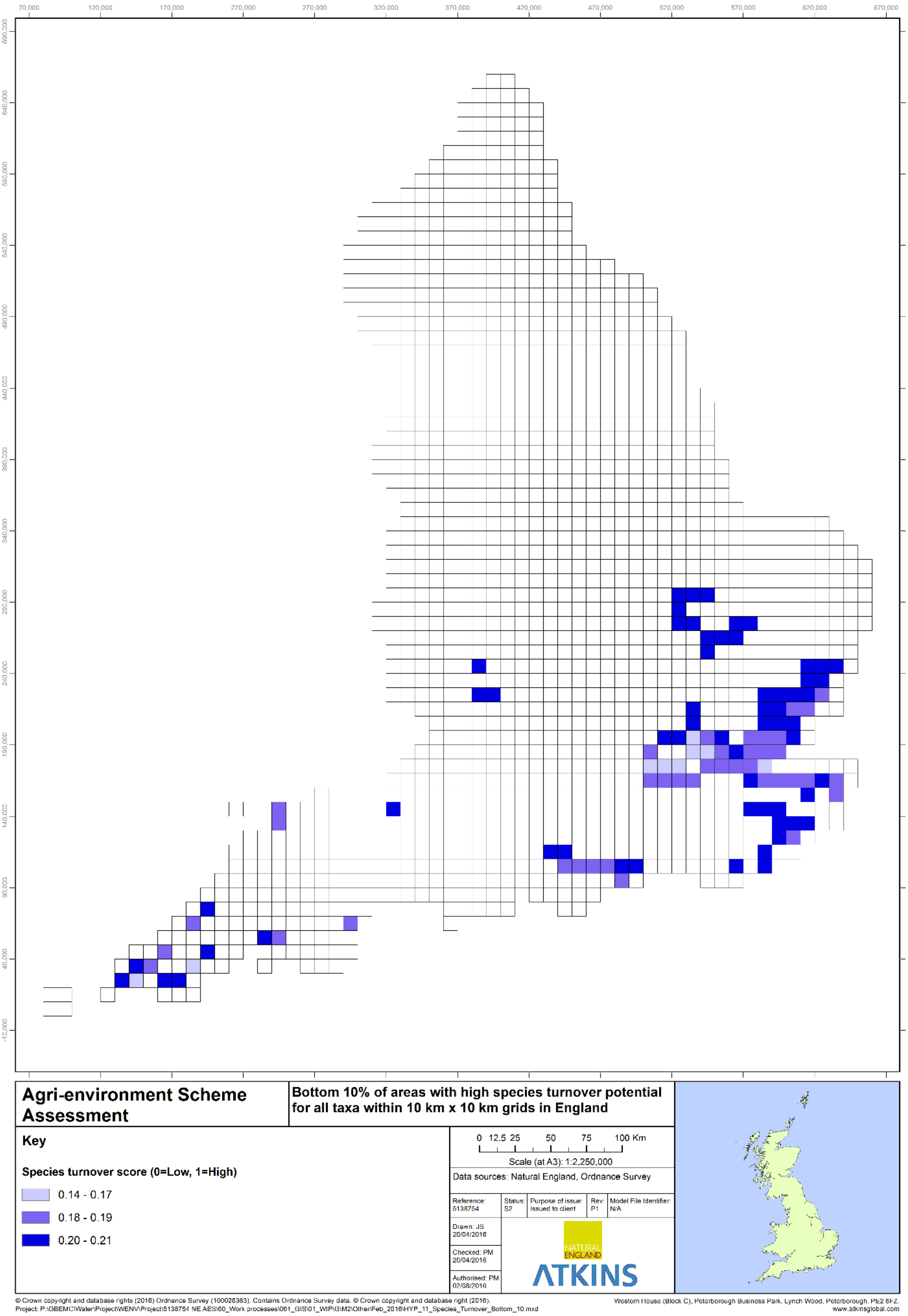
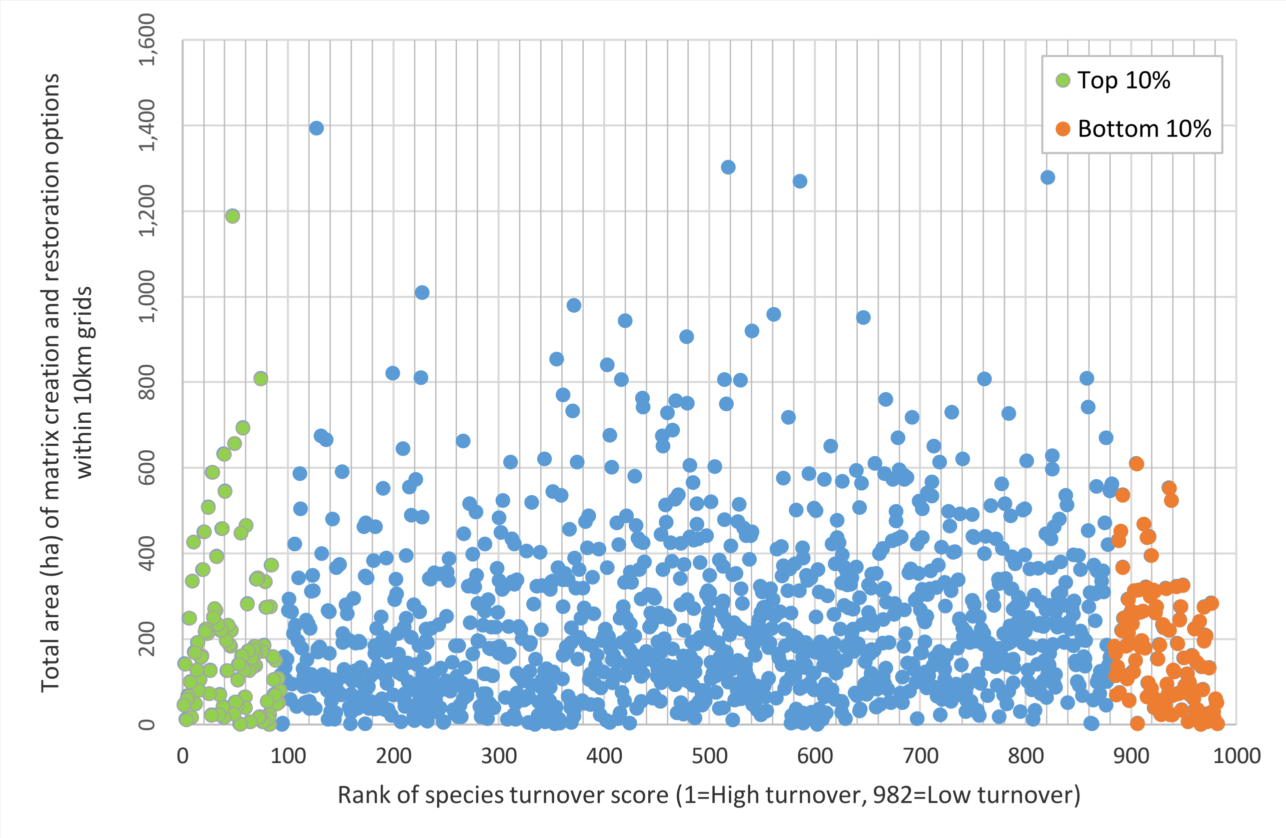


Figure 4-21 below shows the ranked species turnover score for all 982 10 km x 10 km grids against the total area (in hectares) of creation and restoration options in each grid that support the matrix. The graph suggests that there is no clear relationship between matrix creation and restoration options and areas of high or low species turnover. For example, grids of high species turnover contain on average ~204 ha of creation and restoration options (min=0.36 ha, max=1188 ha, sum=19,593 ha) whereas grids of low species turnover contain only slightly less on average (~178 ha) of creation and restoration options (min=0.28 ha, max=609 ha, sum=19,423 ha).

Figure 4-21 Total area (ha) of selected matrix creation and restoration options against species turnover ranks



Monitoring question (national-scale): What is the total area of all options in areas of projected high or low species turnover?

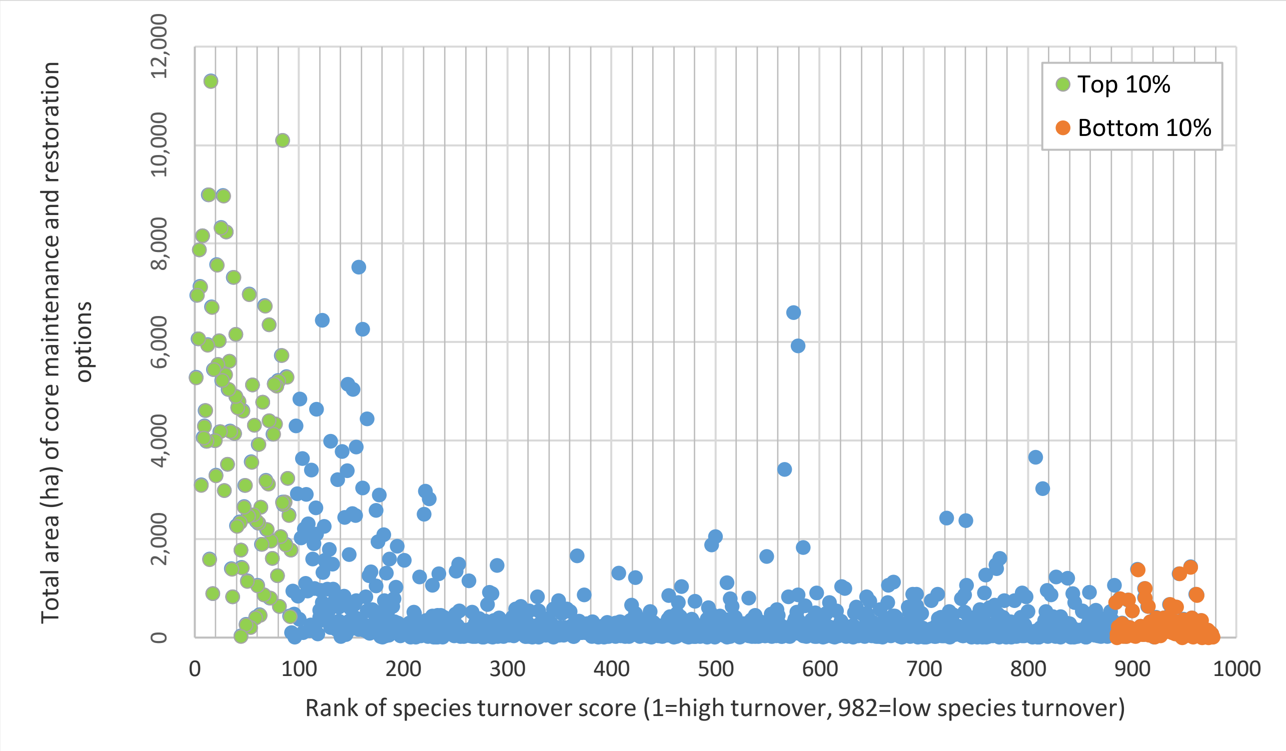
Summary of result: There is significantly greater uptake of maintenance and restoration options within areas of high species turnover (~3,993 ha) than those with low species turnover (~246 ha).

Figure 4-22 shows the ranked species turnover score for all 982 10 km x 10 km grids against the total area (in hectares) of maintenance and restoration options in each grid. Note, not every grid across England (there are 1,509 in total) contains a species turnover score.

The graph suggests that there is a relationship between areas of high species turnover and the total area of maintenance and restoration options in these areas. For example, grids of high species turnover contain on average ~3,993 ha of creation and restoration options (min=26.8 ha, max=11,295 ha, sum=387,352 ha) whereas grids of low species turnover contain much less on average (~246 ha) of creation and restoration options (min=0.1 ha, max=1,430 ha, sum=24,891 ha).

There are some instances where the total amount of option uptake exceeds the total grid area (the maximum area of a 10 km x 10 km grid is 10,000 ha) due to presence of agri-environment scheme data (points) being located close to the edge of grid squares. Our analysis sums the total area of option uptake within each grid irrespective of whether the point is located close to the boundary or not.

Figure 4-22 Total area (ha) of selected maintenance and restoration options against species turnover ranks



E. Restoring ecosystems

Indicator E1: Creation and restoration options will be focused within areas supporting the Outcome 1D objective

Monitoring question (national-scale): What is the proportion and total area of Outcome 1D potential areas covered by creation and restoration options?

Summary of results: The analysis is not possible without polygonised agri-environment scheme data due to the limited coverage of the habitat potential area datasets and the accuracy of the ES scheme data. Analysis of habitat potential should therefore be undertaken at the farm-scale.

Maps of habitat potential were provided by Natural England for the following habitat types (a detailed description of these data layers can be found in Appendix A): blanket bog; coastal saltmarsh; coastal sand dune; coastal vegetated shingle; fen; lowland raised bog; and reedbed.

Each of the individual layers listed above were merged together into a single dataset in order to perform the analysis; this layer represented all areas identified as having habitat potential under Outcome 1D. We then sought to assess the uptake of the selected habitat creation and restoration options overlapping this combined habitat potential layer. However, it was not possible to carry out this analysis successfully due to the use of point data (agreement area centroids) for option uptake meaning that we were unable, with any degree of certainty, to assess the overlap of the selected options with the habitat potential areas. The use of fully geoferenced, polygonised, agri-environment scheme data is therefore pivotal in order to assess the coincidence of creation and restoration options and habitat potential areas.

Table E-11 shows total areas covered by individual habitat potential layers and the % of total area covered by habitat potential areas within individual NCAs.

F. Making species populations more resilient

Indicator F1: Creation options around existing semi-natural areas will create larger conservation sites

Monitoring question (national-scale): What is the proportion and total area of creation options abutting existing habitat and within 0.5 km, 1 km and >1 km of existing priority habitats?

Summary of result: The majority of habitat creation occurs within 1 km of existing priority habitat, but not abutting it. Woodland habitats are an exception, where the vast majority of woodland creation occurs abutting existing priority habitat. However, this should be treated with caution given the relative abundance of woodland patches in England when compared with other habitat types. Where woodland habitat is created, Woodland Creation Grants account for ~81.5% of all woodland habitat creation abutting existing priority habitat. For wetland sites, most habitat creation occurs over 1 km from existing wetlands and the reasons for this are unclear.

Table 4-14 below shows the total area of selected creation options within different proximities of the nearest patch of any priority habitat. Note, the <100 m category was included to capture habitat created close to (abutting) existing priority habitats; this was necessary due to the use of point (field centroid) agri-environment scheme data. Table 4-14 suggests that the majority of habitat creation occurs within 1 km of existing priority habitat, but not abutting it (i.e. not within <100 m). Woodlands are an exception as the vast majority of woodland habitat creation occurs abutting existing priority habitat. However, this result should be treated with caution given the relative abundance of woodland habitats in England when compared with other habitats. Where woodland habitat is created, Woodland Creation Grants account for ~81.5% of all woodland habitat creation abutting existing priority habitat. For wetland sites, most habitat creation occurs over 1 km from existing wetlands; the reasons for this are unclear.

One aim of future agri-environment scheme delivery could therefore be to increase the proportion of habitat creation within closer proximity of existing priority habitat, where possible. In order to determine precisely the extent of habitat creation close to existing priority habitat (i.e. abutting), fully georeferenced (polygonised) agri-environment data is required. At the farm-scale, this is more likely to be able to be assessed.

Table 4-14 Total area of selected creation options within different proximities of existing priority habitats

Buffer	Total area (ha) of selected core creation options, showing proximity to the nearest patch of existing priority habitat							
	<100 m		<0.5 km		< 1 km		> 1 km	
Broad habitat type	ES	EWGS	ES	EWGS	ES	EWGS	ES	EWGS
Coastal	120.5	-	414	-	560.1	-	58.3	-
Grassland	605.7	-	2,523	-	3,386	-	1,621	-
Heathland	43.3	-	234	-	254.1	-	27.4	-
Upland	1,574	-	2,130	-	2,496	-	64.9	-
Wetland	147.8	-	236.5	-	357.6	-	604.4	-
Woodland	1,254	5,518	2,935	106.3	3,830	267.4	12,323	2,564
Mean	624.2	-	1,412.1	-	1,814	-	823.3	-
Min	43.3	-	234	-	254.1	-	27.4	-
Max	1,574	-	2,935	-	3,830	-	2,564	-
Total	3,745	-	8,473	-	10,884	-	4,940	-

Figure 4-23 overleaf shows the breakdown of creation options within 100 m of existing priority habitat and the level of uptake. The options cited in this figure are as follows:

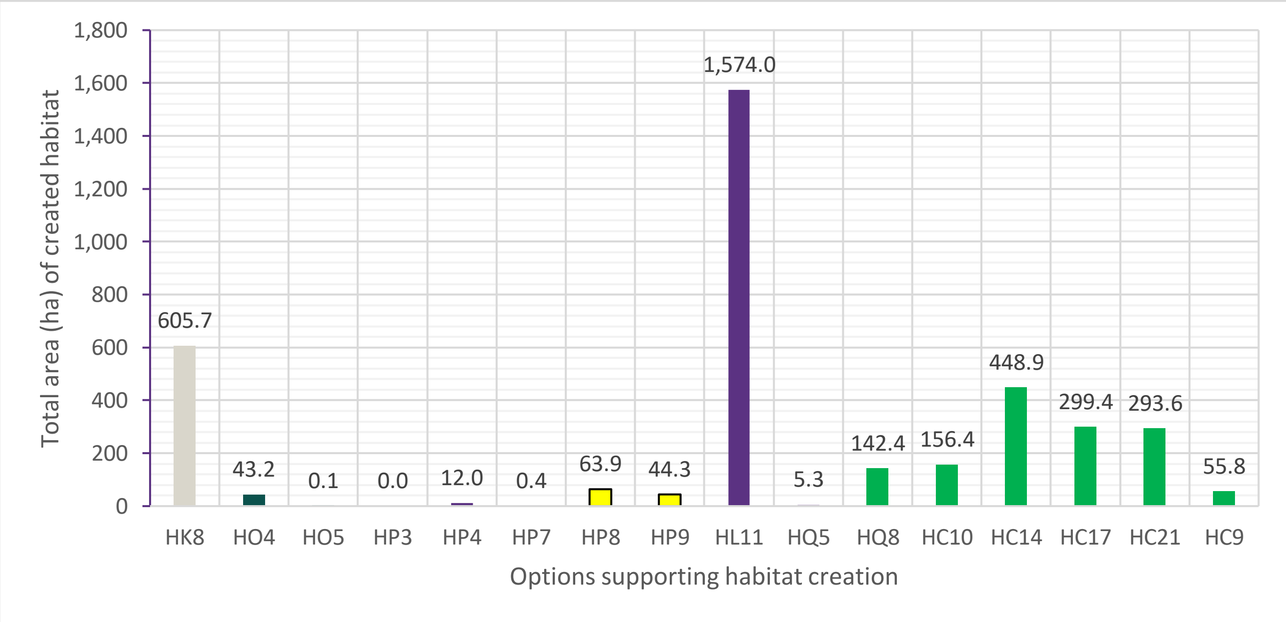
- HK8 – Creation of species-rich, semi-natural grassland;
- HO4 – Creation of lowland heathland from arable or improved grassland;
- HO5 – Creation of lowland heathland on worked mineral sites;
- HP3 – Creation of vegetated shingle and sand dune on arable;
- HP4 – Creation of vegetated shingle and sand dune on grassland;
- HP7 – Creation of inter-tidal and saline habitat on arable land;
- HP8 – Creation of inter-tidal and saline habitat on grassland;
- HP9 – Creation of inter-tidal and saline habitat by non-intervention;
- HL11 – Saltmarsh livestock exclusion supplement;

- HQ5 – Creation of reedbeds;
- HQ8 – Creation of fen;
- HC9 – Creation of woodland in the SDA;
- HC10 – Creation of woodland outside of the SDA & ML;
- HC14 – Creation of wood pasture;
- HC17 – Creation of successional areas and scrub; and
- HC21 – Creation of traditional orchards.

Clearly there is significant variation between the individual creation options on the extent to which they are used in proximity to existing habitats. Further research is recommended to investigate the reasons for this and whether any changes to scheme delivery should be sought.

Table E-12 shows the number, and total area, of creation options within different proximities from existing priority habitat within each NCA.

Figure 4-23 Total uptake (ha) of individual selected creation options within 100 m of existing priority habitat



G. Improving water quality and reducing flood risk

Indicator G1: Matrix options for soil protection will be focused in Water Quality Priority Areas

Monitoring question (national-scale): What is the proportion and total area of Water Quality Priority Areas covered by appropriate matrix options?

Summary of result: Across all 10 km x 10 km grids that contain a high priority WQPA, uptake of options that support soil protection within these areas is ~4.8%. The Pennines and west Midlands generally see the most comprehensive coverage.

Figure 4-24 shows the total area of high priority Water Quality Priority Areas within each 10 km x 10 km grid in England. Scoring for each of the following water quality issues was undertaken for the CS scheme by Natural England and used in targeting agri-environment schemes:

- Groundwaters at risk of Nitrate Pollution;
- Rivers at risk of nitrate pollution;
- Groundwaters at risk of pesticide pollution;
- Rivers at risk of pesticide pollution;

- Faecal indicator species risks;
- Sediment risks; and
- Phosphate risks.

Each of these risks are weighted and the amount of pollutants associated with each derived. A categorisation is then applied (high, medium or low) which represents the priority for CS targeting; these areas therefore represent the locations where agri-environment schemes should be targeted to reduce the impacts of water quality issues. Figure 4-25 shows the proportion of high priority WQPA covered by options that support soil protection within each 10 km x 10 km grid. To calculate these values, the total area of WQPA was calculated in each grid and the total area of options that coincided with these areas was summed. The map suggests that uptake of options that support soil protection (and that may provide water quality benefits) are greatest in the Pennines, Lake District, Cotswolds and Wiltshire. Across all 10km x 10km grids that contain a high priority WQPA, the mean coverage of WQPA by options is 4.8% (min:0.1%, max:52.9%).

Figure 4-24 Total area of (high priority) Water Quality Priority Areas within 10 km x 10 km grids

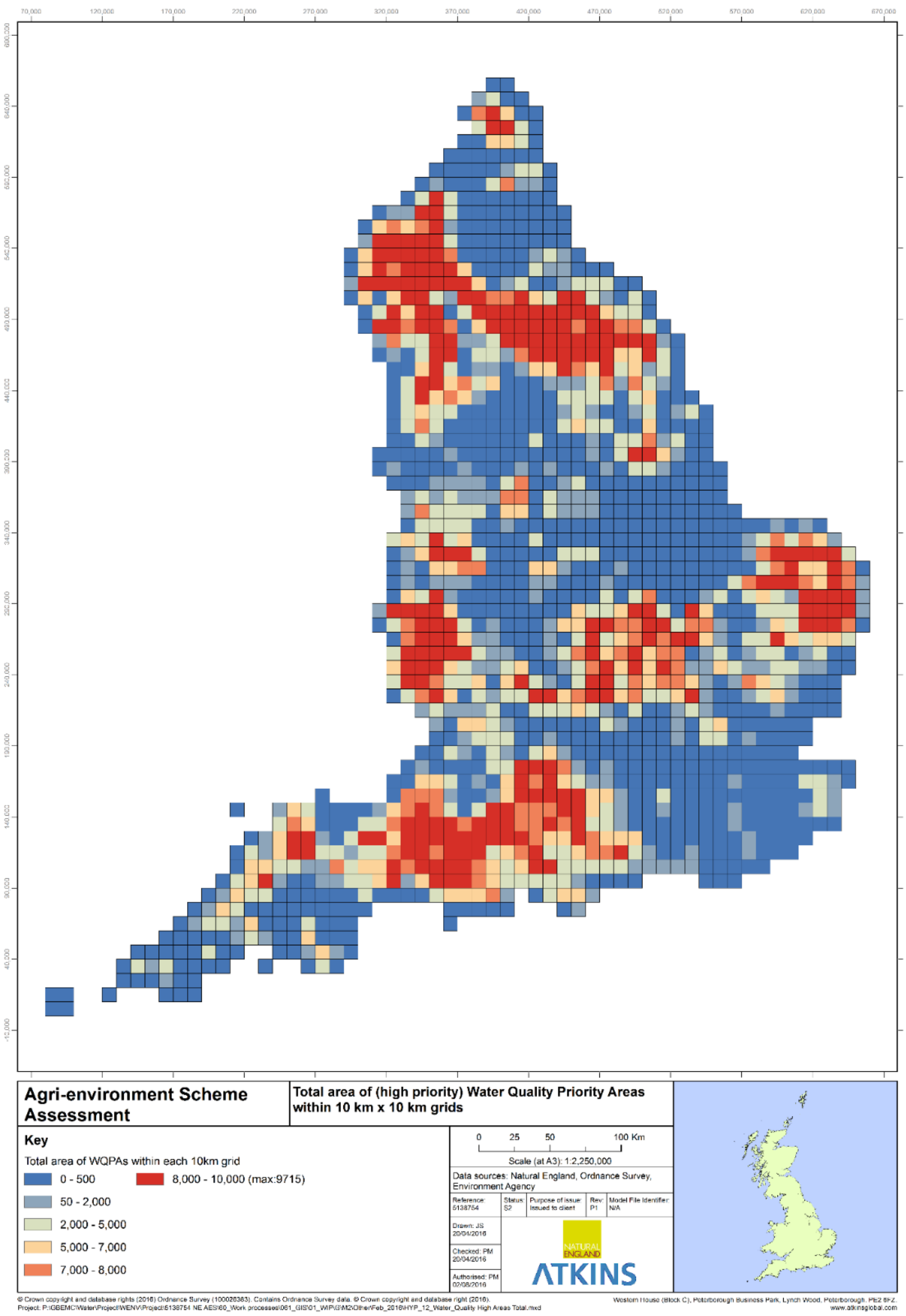
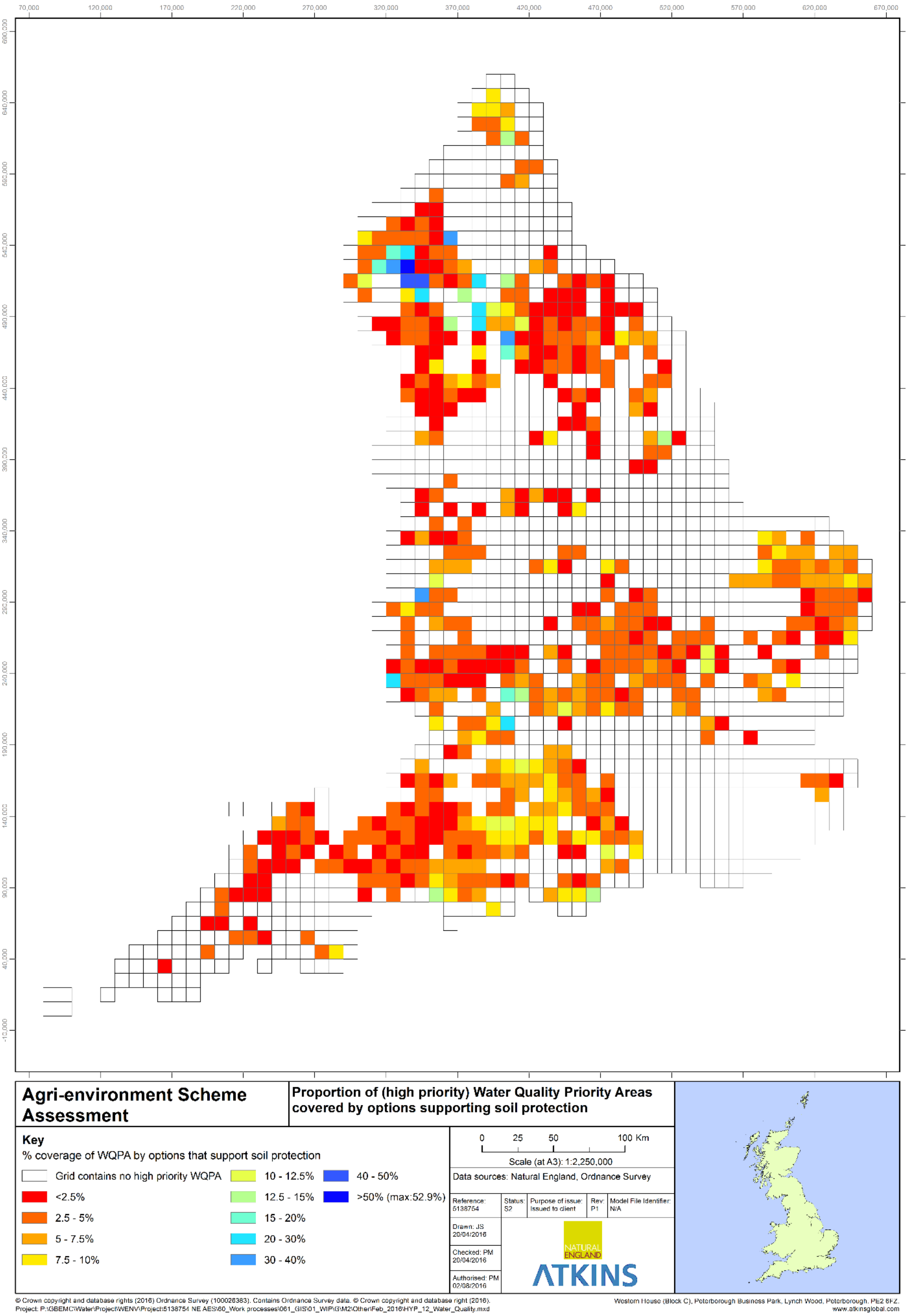


Figure 4-25 Proportion of (high priority) Water Quality Priority Areas covered by options supporting soil protection



H. Storing and sequestering carbon

Indicator H1: Agri-environment schemes contribute to the storage and sequestration of carbon

Monitoring question (national-scale): What is the proportion (and total area) of blanket peat and peat soils with appropriate options?

Summary of result: Only blanket peat and peat soils were considered in this analysis. The majority of blanket peat soils (72.7%) are covered by selected creation and restoration options whilst the majority of peat soils (90.7%) are not covered by any selected creation and restoration options. Across all option types (i.e. creation, restoration and maintenance), 85.5% of blanket peat soils are covered by options whilst uptake on peat soils is substantially lower (17.7%). Therefore, the selected agri-environment scheme options used in this analysis are shown to not be implemented on most peat soils. The reasons for this merit further investigation.

Please note, to isolate peat soils only, only 'peat' and' 'blanket peat' have been considered in this analysis from NatMap Vector's 'Simple description', not any of their derivatives (e.g. 'peat to loam over granite' or 'seasonally wet deep peat to red loam' etc.).

Table 4-15 shows the uptake of creation and restoration options on peat soils within the UAA whilst Table 4-16 shows the uptake of maintenance options only within the UAA. Appendix D lists the individual options selected using the Excel tool. In total, there are 267,536 ha of blanket peat and 121,422 ha of peat within the UAA. In the case of blanket peat, 72.7% (194,461 ha) is covered by one option: HL10 (restoration of moorland) whilst 27% (72,297 ha) is not covered by any of the selected creation and restoration options. In contrast, 90.7% (110,092 ha) of peat soils are not covered by any of the selected creation and restoration options, whilst only 4.5% is covered by HL10.

Table 4-15 Total uptake of selected creation and restoration options on peat soils

Creation and restoration options within the UAA			
Blanket peat	% of all blanket peat	Peat	% of all peat
0 (ha) covered by HK11	0.0%	887.7 (ha) covered by HK11	0.73%
0 (ha) covered by HK12	0.0%	745.4 (ha) covered by HK12	0.61%
0 (ha) covered by HK13	0.0%	908 (ha) covered by HK13	0.75%
0 (ha) covered by HK14	0.0%	138.4 (ha) covered by HK14	0.11%
51.9 (ha) covered by HK7	0.0%	613.6 (ha) covered by HK7	0.51%
0 (ha) covered by HK8	0.0%	72.5 (ha) covered by HK8	0.06%
194,461 (ha) covered by HL10	72.7%	5,491 (ha) covered by HL10	4.52%
711.4 (ha) covered by HL11	0.3%	0 (ha) covered by HL11	0.00%
1.29 (ha) covered by HO2	0.0%	31.4 (ha) covered by HO2	0.03%
1.46 (ha) covered by HO3	0.0%	11.3 (ha) covered by HO3	0.01%
0 (ha) covered by HO4	0.0%	0 (ha) covered by HO4	0.00%
0 (ha) covered by HO5	0.0%	0 (ha) covered by HO5	0.00%
12.4 (ha) covered by HQ10	0.0%	1,525 (ha) covered by HQ10	1.26%
0 (ha) covered by HQ4	0.0%	27.6 (ha) covered by HQ4	0.02%
0 (ha) covered by HQ5	0.0%	55.7 (ha) covered by HQ5	0.05%
0 (ha) covered by HQ7	0.0%	656.8 (ha) covered by HQ7	0.54%
0 (ha) covered by HQ8	0.0%	176.2 (ha) covered by HQ8	0.15%
72,297 (ha) not covered by options	27.0%	110,092 (ha) not covered by options	90.7%
Total: 267,536 ha	Total: 100%	Total: 121,422 ha	Total: 100%

In the case of maintenance options only, 87.5% (234,122 ha) of blanket peat is not covered by any of the selected maintenance options, with 12.5% (33,362 ha) covered by HL9 (maintenance of moorland). In the case of peat soils uptake is lower with 91.6% (111,231 ha) not covered by any selected maintenance option and only a handful of other options having any uptake.

In combination (i.e. across all creation, restoration and maintenance options) 85.5% (228,652 ha) of blanket peat is covered by options whilst only 17.7% (21,531 ha) of peat is covered by options. Therefore, the majority of peat soils are not the focus for (selected) options but there is potential for improvement. The reasons for this merit further investigation.

Checks on the condition of peat and blanket peat soils should be undertaken at the farm-scale to assess the effectiveness of the management and the likely implications for carbon storage.

Table 4-16 Total uptake of selected maintenance options on peat soils

Maintenance options within the UAA			
Blanket peat	% of all blanket peat	Peat	% of all peat
0 (ha) covered by HK10	0.00%	3,165 (ha) covered by HK10	2.61%
47.9 (ha) covered by HK6	0.02%	571 (ha) covered by HK6	0.47%
0 (ha) covered by HK9	0.00%	3,917 (ha) covered by HK9	3.23%
33,362 (ha) covered by HL9	12.5%	252 (ha) covered by HL9	0.21%
3.5 (ha) covered by HO1	0.00%	20.1 (ha) covered by HO1	0.02%
0 (ha) covered by HQ2	0.00%	no area in data (ha) covered by HQ2*	0.00%
0 (ha) covered by HQ3	0.00%	591 (ha) covered by HQ3	0.00%
0 (ha) covered by HQ6	0.00%	1,394 (ha) covered by HQ6	0.49%
0 (ha) covered by HQ9	0.00%	280 (ha) covered by HQ9	1.15%
234,122(ha) not covered by options	87.5%	111,231 (ha) not covered by options	91.6%
Total: 267,536 ha	Total: 100%	Total: 121,422 ha	Total: 100%

*the options data does not contain area values for this particular option (maintenance of ponds of high wildlife value >100 sq. m)

Coverage of creation and restoration options over blanket peat is most abundant in the North Pennines (NCA 10) (54,461 ha of 72,750 ha or 74.9%). The Fens (NCA 46) contains the greatest amount of peat (25,378 ha) but only has uptake of 909 ha (3.6%). Uptake is high on peat soils within North Pennines (NCA 10) (93.9%. 2,833 ha of 3,016 ha) and Tyne Gap and Hadrian's Wall (NCA 11) (54.3%, 244ha of 450 ha) but is very low in Lancashire and Amounderness Plain (NCA 32) (0.8%, 107 ha, 14,141 ha).

For maintenance options, the North Pennines (NCA 10) has the greatest amount of blanket peat (72,750 ha where uptake is 10,430 ha or 146%) followed by the Yorkshire Dales (NCA 21) (60,715 ha where uptake is 12,881 ha or 21.2%). For peat soils, maintenance options cover the greatest area in The Fens (NCA 46) (25,378 ha) and Lancashire and Amounderness Plain (NCA 32) (14,141 ha) but uptake is low at 8.7% (2,209 ha) and 0.9% (129 ha), respectively. Note, the coverage of blanket peat is greater than 100% in the North Pennines NCA due to the comparison of point (agri-environment) against polygonised (NCA) data; in this case a number of maintenance options (which themselves cover large areas) are located just inside this NCA meaning that, in the analysis presented here, these options would be considered to fall wholly inside this NCA when totalling areas. In reality, it's more likely that the option coverage would span across this boundary bit this nuance is unable to be accounted for using the available data. Instances where this occurs are however small.

I. Targeting and applying interventions in a cost-effective and adaptive way

Indicator I1: Adaptation in the natural environment will be consistent with agricultural adaptation

Monitoring question (national-scale): What is the area of core habitat creation options within each ALC grade?

Summary of result: Excluding Woodland Creation Grants, uptake of options that support habitat creation is generally greater within the highest quality (grades 1-3) agricultural land grades (54%) than the lower grades (grades 4 and 5) (46%). When Woodland Creation Grants are included, uptake is similar although there is slightly more uptake in the higher (60%) than the lower (40%) grades.

Figure 4-26 shows the total uptake of core creation options within individual ALC grades (Appendix D lists the individual options selected using the Excel tool). WCGs have been excluded from this figure as the relative proportion of these options far outweighs that of any other options (nearly half of all creation option uptake is via WCGs). For example, there are 19,427 ha of WCGs alone giving a total of 40,243 ha of creation options. Omitting the WCGs gives a total of 20,816 ha of creation options within the UAA.

Overall, ~44.2% (9,203 ha) of all core creation options occur on grade 3 (Good/Moderate quality) whilst just over half (54.4% or 11,317 ha) occur on grades 1-3 combined (the highest quality agricultural land). Therefore, ~45.6% (9,500 ha) of core creation options, by uptake, are located on the lowest quality agricultural land (grades 4 - Poor quality and 5 - Very poor quality).

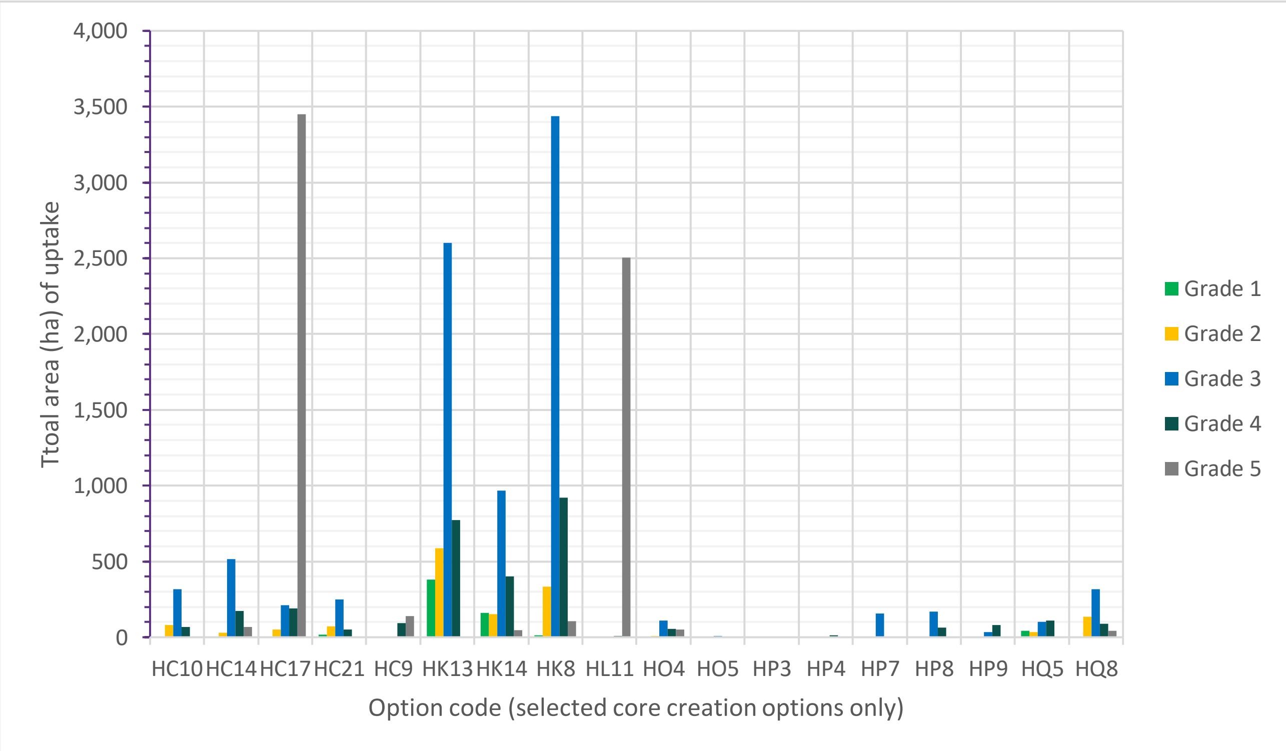
At the option level, WCGs cover the greatest total area (19,247 ha or 48.3%) with the majority of this (10,731 ha or 55.2%) located within grade 3. This is followed by HK8 (creation of species-rich, semi-natural grassland) (4,810 ha or 12% of total area), HK13 (creation of wet grassland for breeding waders) (4,339 ha or 10.8%) and HC17 (creation of successional areas of scrub) (3,911 ha or 9.7%). In the case of HK8 and HK13, the majority of core creation options are located in grade 3 with 71.4% (3,436 ha) and 59.9% (2,599 ha), respectively, whilst HC17 is predominantly located within grade 5 (3,451 ha or 88.3%). HL11 (creation of upland heathland) is the only other core creation option that covers more than 5% (it covers 2,515 ha or 6.2%) of the total area and it is almost entirely located within grade 5 (2,506 ha or 99.7%).

Excluding WCGs, HK8 covers the greatest total area (4,810 ha or 23.1%) with majority of this located within grade 3. HK13 and HK17 cover similar total areas (20.8% or 4,339 ha and 18.8% or 3,911 ha, respectively) but HK13 is primarily located on grade 3 land (~60%) whilst HK17 is predominantly found on grade 5 land (~88%). Figure 4-26 shows the uptake of each core creation option by agricultural land grade (excluding WCG).

This analysis can be developed by:

- Considering the areas of habitat creation relative to the extent of each ALC grade;
- At the farm-scale, on areas of habitat creation, assessing the true productive potential of the soil: i.e. whether the ALC grade truly reflects its potential agricultural productivity and hence the extent of any conflict between alternative uses of the land; and
- Improving the understanding of the potential for trade-offs between alternative uses of the land (as described in Section 2).

Figure 4-26 Total area (ha) of selected core creation uptake within different agricultural land grades



5. Developing the farm-scale element of the monitoring framework

This section describes the development of the farm-scale element of the monitoring framework in terms of the methods used, what we intend to monitor at the farm-scale and how we intend to measure it.

5.1.1. Methods

5.1.1.1. What to monitor (adaptation indicators)

At the farm-scale, monitoring is required to provide:

- Ground-truthing of the national baseline assessment;
- An assessment of habitat condition;
- An assessment of individuals' (i.e. Advisors', farmers'/land managers' attitudes) (e.g. to scheme flexibility); and
- An assessment of what is appropriate in the farm/landscape context (e.g. is placement of the option(s) contributing to flood risk management?)

To enable a better understanding of the issues of scale and how our adaptation response(s) might vary with it (and, by association, the monitoring approach(es) that might be required), a number of experts from Natural England, the Environment Agency and the Forestry Commission were invited to a workshop. The participants were split into two groups and each group was provided with a set of pre-printed cards listing over 30 different adaptation strategies. The groups were tasked with sticking each of the cards (plus blank cards which they were encouraged to use if they felt a particular strategy was missing) onto a simple Venn diagram that displayed three circles representing each of the following scales: national, catchment/landscape and farm/local. Following this, the groups were presented with a series of catchment/landscape scale (10 km x 10 km) maps which contained information (such as the agri-environment scheme and EWGS options present within the area, information on flood risk, agricultural land quality, BAP habitats and land cover) for a number of different locations. These locations were representative of different types of landscape i.e. high/low intensity agriculture, high/low fragmentation, high/low species refugia potential. The groups were then asked to describe how they thought agri-environment schemes might be contributing to adaptation, where the schemes could be better targeted (if at all) and to identify recommendations for improving adaptation.

The outputs (see Appendix F) further reinforced the influence, and importance, of scale in the context of understanding (and interpreting) the potential contribution of agri-environment schemes to climate change adaptation. Another finding was that the participants found it particularly difficult to interpret strategies and impacts at the catchment/landscape scale; they frequently either wanted more or less detailed information, such as being able to set the area within the context of its surroundings and/or more detailed information at the farm level (e.g. native or non-native species likely to move into the area with climate change). For example, for the strategy "control invasive species" many of the participants agreed that a national-level strategy for invasives was important but frequently the suggestion was made that more information, in the form of data and monitoring strategies, were required at the local (farm) scale in order to put the strategy in context. As a result, one of the conclusions was that information at the catchment/landscape scale was often more easily interpreted by looking at the farm-scale and then setting this within the context of the wider environment. The workshop therefore highlighted the importance of carefully considering the monitoring requirements that might be needed and the scales at which individual monitoring measures might be most appropriate.

The assessment of the potential for monitoring at the national-scale has identified that some of the adaptation indicators are not suited to a national analysis (see Table 2-60). For these, the farm-scale monitoring will be particularly important:

- Indicator A2: Condition of habitats
- Indicator A6: Riparian shading of freshwater habitats;
- Indicators B3 and B4: Woodland options to reduce habitat fragmentation
- Indicator B6: Enhancement of ecological networks
- Indicator D2: Species turnover
- Indicator F2: Topographic heterogeneity

- Indicators G2 and G3: Flood risk
- Indicator I2: Scheme flexibility; and
- Indicator I3: The ability of schemes to accommodate changing conditions

For other indicators, it was noted that whilst a broader (national-scale) assessment of the outcome would help identify changes or trends, local scales were also likely to be important in helping to interpret impacts and in identifying appropriate adaptation actions (and the requirements for doing so). As others have noted (UKCIP, 2006), when considering the appropriateness of a suite of adaptation options there are often concerns related to risks associated with their selection and implementation. For example, is the identified adaptation necessary or too much (over adaptation), less than ideal or not enough (under adaptation), restrictive or simply wrong and unjustified? Therefore, assessing (and measuring) the appropriateness of adaptation would be difficult at the national-scale but it was noted that this is very important in helping to determine the effectiveness of adaptation. Scale is therefore an important consideration, particularly when trying to understand and interpret resilience and vulnerability to climate change and the adaptation strategy or response that may be required (Section 2.1.1.1).

A second workshop was held to discuss the development of the monitoring framework and, specifically, a subset of the adaptation indicators used in the baseline assessment and their likely monitoring requirements. The initial subset of outcomes to discuss at the workshop was decided upon in conjunction with the Steering Group. As it was not possible to discuss all of the adaptation indicators in the time available, some were amalgamated where they focussed on similar topics (i.e. protecting the most important sites). Further, as some attendees were unlikely to be familiar with specific terminology (e.g. 'Outcome 1D') some of the language was also simplified, where necessary. In total, eight indicators were discussed:

- Indicators A1/A3: Agri-environment options will support SSSIs and other priority habitats;
- Indicators B1/B2: Agri-environment options will reduce habitat fragmentation;
- Indicators A4/A5: Restoration and maintenance options will support highly sensitive habitats;
- Indicator C1: Restoration and creation of more sensitive habitats will be focussed on refugia;
- Indicator G1: Agri-environment options will support improvement of water quality;
- Indicator E1: Creation and restoration options will be focused within areas supporting the Outcome 1D objective;
- Indicator I2: Options will be implemented in a flexible way to facilitate adaptive management; and
- Indicator I3: Agri-environment options will accommodate change where appropriate.

All of the experts that attended the first workshop were invited to the second workshop, alongside some additional expertise where required (e.g. environmental monitoring specialists, land management advisors). The attendees were split into two groups and presented with a simple proforma that described the adaptation indicator and associated question at the national-scale. They were then asked how the question might change or need to be reinterpreted with scale (i.e. at both catchment/landscape and local/farm-scales). The resulting outputs (Appendix F) provided a starting point for the development of the monitoring framework and the adaptation indicators that were to be included in the monitoring framework. Following the workshop, four telephone interviews were also carried out with Natural England Advisors to sense-check the outputs and to discuss any additional indicators for consideration. Following this, a final set of indicators for monitoring, informed by the workshop and Advisor interviews, were identified (these are presented in Table 5-1).

Table 5-1 Adaptation indicators, monitoring questions and purpose of farm-scale monitoring

Category	Adaptation indicator	Monitoring question (farm-scale)	Purpose of farm-scale monitoring
A. **Protecting the most important and vulnerable sites**	A1. Maintenance and restoration options will be coincident with priority habitats	Same as national-scale (What is the proportion of priority habitat covered by maintenance and restoration options?)	Ground-truthing of national assessment
	A2. Priority habitats will be in better condition within areas managed under agri-environment schemes	What is the condition of habitats managed under agri-environment schemes?	Assessment of condition
	A3. Agri-environment schemes will support SSSIs	What proportion of priority habitat is assessed as in good condition?	Assessment of condition
	A4. Restoration and maintenance options will support highly sensitive habitats	Same as national-scale (Of habitats with High, Medium or Low (and 1-5) sensitivities, what is the proportion under appropriate	Ground-truthing of baseline assessment Assessment of condition

Category	Adaptation indicator	Monitoring question (farm-scale)	Purpose of farm-scale monitoring
		restoration and maintenance options?)	
	A5. Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)	Same as national-scale (What is the area of creation option uptake by sensitivity class?)	Ground-truthing of baseline assessment Assessment of condition
	A6. Agri-environment management will create shade for rivers where this is a priority for the freshwater habitat	Total (canopy) area of new trees that have been planted within 10 m of the river bank?	Assessment of appropriateness
B. **Reducing fragmentation and enhancing ecological networks**	B1. Creation options will reduce fragmentation	Same as national-scale. (What is the proportion and total area of appropriate creation options in each fragmentation buffer?) In addition, what is the quality of the created habitat?	Ground-truthing of baseline assessment Assessment of appropriateness
	B2. Restoration options will support the reduction of fragmentation	What is the quality of the restored habitat?	Ground-truthing of baseline assessment Assessment of condition
	B3. Woodland creation options will help to reduce woodland fragmentation	What is the proportion and total area of appropriate creation options in each buffer? What is the quality of the created habitat?	Assessment of appropriateness Ground-truthing of baseline assessment.
	B4. Woodland restoration and maintenance options will support the reduction of woodland fragmentation	What is the quality of the restored habitat?	Ground-truthing
	B5. Matrix options to restore or create features should be focussed in areas of high fragmentation	What is the proportion and total area of appropriate creation and restoration matrix options in the high fragmentation buffer?	Ground-truthing (do the newly created features improve connectivity between habitat patches)
	B6. Creation options are located within 1 km of core areas.	Is the option sited appropriately to enhance ecological networks? What is the condition of the newly created habitat?	Assessment of appropriateness. Assessment of condition
	B7. Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species	What is the proportion of appropriate woodland creation options that fall within 1 km of woodland habitat networks?	Assessment of appropriateness.
C. **Protecting refugia**	C1. Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia	What proportion of eligible land is covered by appropriate options? Does current management enhance refugia characteristics?	Assessment of condition
D. **Planning for potential changes in species' ranges and assemblages**	D1. Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions	What proportion of agreements contain appropriate management designed for species for which we think the area will be important?	Assessment of individuals' attitudes
	D2. Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations	Same as above with a focus on the leading edge of species populations.	Assessment of individuals' attitudes

Category	Adaptation indicator	Monitoring question (farm-scale)	Purpose of farm-scale monitoring
E. **Restoring ecosystems**	E1. Creation and restoration options will be focused within areas supporting the Outcome 1D objective	Same as national-scale (What is the proportion and total area of Outcome 1D potential areas covered by creation and restoration options?)	Assessment of condition (is the management helping to restore the ecosystem on the area shown by the Outcome 1D targeting dataset)?
F. **Making species populations more resilient**	F1. Creation options around existing semi-natural areas will create larger conservation sites	Same as national-scale (What is the proportion and total area of creation options abutting existing habitat and within 0.5 km, <1 km and >1 km of existing priority habitats? In addition, what is the average distance between existing habitat patches and creation options? What is the average size of habitat patches on site as a result of the new habitat creation?	Ground-truthing of baseline assessment
	F2. Creation options increase the topographic heterogeneity of habitats	What is the degree of heterogeneity of habitats on farm? (assess habitat structure and aspect on different patches of the same habitat and rate for similarity-difference)	Assessment of appropriateness (i.e. has the creation of new habitat increased the variety of conditions for that habitat type on the farm?)
G. **Improving water quality and reducing flood risk**	G1. Matrix options for soil protection will be focused in Water Quality Priority Areas	To what extent do the options currently used on farm provide improvements to water quality?	Assessment of appropriateness (e.g. of location)
	G2. There will be a greater concentration of relevant agri-environment schemes options within flood prone areas to reduce flood risk	Is the choice and placement of options optimal in reducing flood risk on, and outside of, the farm?	Assessment of appropriateness
	G3. Agri-environment schemes will support the objectives of the Woodlands for Water programme	Is the choice and placement of options optimal in reducing flood risk on, and outside of, the farm?	Assessment of appropriateness
H. **Storing and sequestering carbon**	H1. Agri-environment schemes contribute to the storage and sequestration of carbon	Same as national-scale (What is the proportion (and area) of blanket peat and peat soils with appropriate options on? In addition, what is the condition of peat soils within the holding?	Ground-truthing of baseline assessment Assessment of appropriateness
I. **Targeting and applying interventions in a cost-effective and adaptive way**	I1. Adaptation in the natural environment will be consistent with agricultural adaptation.	Same as national-scale. (What is the area of core habitat creation options within each Agricultural Land Classification (ALC) grade?) In addition, what was the quality of soil for farming prior to habitat creation?	Ground-truthing of baseline assessment Farmer attitudes: what was the agricultural value of the land given over to habitat creation?
	I2. Options will be implemented in a flexible way to facilitate adaptive management	Have farmers been unable to meet management requirements or dates due to weather? Have they been able to achieve favourable condition of habitat?	Assessment of individuals' attitudes
	I3. Agri-environment options will accommodate change where appropriate	How are longer-term changes accommodated (if at all) in agreements?	Assessment of individuals' attitudes

5.1.1.2. What data are required?

For many of the indicators listed above, farm-scale assessment will be required in order to ground-truth changes and/or trends that have been identified at the national-scale. Alongside many of the national-scale datasets (Section 3.1.1.1) some additional data will also be required in order to facilitate local assessment and scheme monitoring. As a consequence, there is a need for datasets beyond those already identified that are non-spatial in nature but fundamental in addressing some of the indicators described (Table 5-1), such as those that focus on flexibility (indicator I2) and accommodating change in scheme design (indicator I3).

What follows is a description of the datasets that may be used to facilitate monitoring of these indicators at the farm-scale and some of the gaps where additional data is required; the latter will form recommendations for data collection required as part of the proposed farm-scale element of the monitoring framework.

5.1.1.2.1. Additional data requirements

A variety of different data is created and collected on-farm as part of the scheme application process and existing monitoring that subsequently takes place (Section 1.1). All of this data is available to Natural England advisors and their colleagues via internal systems, such as GENESIS, which allows users to identify individual agreements and explore a wide variety of information; much of this available data is described below.

Under the Higher Level tier of ES an environmental audit or **Farm Environment Plan (FEP)** was undertaken, normally by an independent surveyor. The FEP provides an audit of environmental features (e.g. presence, and condition, of a priority habitat or species or other interest feature) on the holding alongside a variety of other data, including: a farm habitat summary sheet that highlights the total farm area, a list of designated habitats and their extent; a map (usually to scale 1:10,000 or larger) that identifies the location of key environmental, ecological and/or heritage features on the farm and the location of habitats. The identified features are then linked to a variety of proposed management measures (HLS options) by a Natural England advisor. The new CS scheme, which is replacing ES, includes a Baseline Environmental (Higher Tier) Assessment (BEHTA), as a replacement for the FEP. Hence, it is assumed that a similar breadth of information will be available for future agri-environment agreements.

Following this, the advisor sets management prescriptions for each of the selected options. **Prescriptions** are guidelines that the land owner must adhere to in order to ensure that they meet the management requirements for each option, there are usually multiple prescriptions per option (Natural England, 2013c). However, ES focusses on achieving outcomes, not just following prescriptions, so adaptive management is used to provide land managers with flexibility as required. When management prescriptions are unable to be met land managers are able to change the choice or location of option(s), subject to Natural England's approval, using an amendment. **Amendments** are avoided wherever possible and typically are not expected to be made more than once in any five-year agreement term (Natural England, 2013c). However, they are recorded and may be revisited to pull out information of interest. Where only minor or temporary changes are needed to prescriptions, a **derogation** is used (these are also recorded). Examples of derogations include permission to control serious weed infestations using herbicides, a relaxation of a time-based prescription, permission to alter cutting or cultivation prescriptions due to practical problems.

Other data sources available at the local scale include those relating to protected habitats, such as **Condition Assessments** of SSSIs. Monitoring and reporting of SSSIs is a vital component of Natural England's statutory responsibility to conserve and protect them. Natural England assesses the condition of SSSIs using Common Standards Monitoring (CSM) developed by the JNCC for the whole of the UK (Natural England, 2013d). For the purposes of monitoring, SSSIs are split into one or more monitoring units and condition recorded at this level for all features. The use of units allows better linkage to be made between the condition of the feature and the management in place (which may be acting at different spatial scales). Whilst condition is recorded at the unit level, some features (e.g. bird populations or woodland) are assessed across the whole site and then considered within the context of factors influencing individual units (Natural England, 2013d). SSSIs are assessed on a number of criteria, including condition. For each SSSI, a list of notified features is created, together with their attributes and targets, and compiled into a Favourable Condition Table (FCT). Favourable condition is reached when all of a site's notified features are assessed as meeting the required target. SSSI condition surveys are therefore a valuable resource in assessing and monitoring the condition (and factors influencing condition) of SSSIs at local/farm-scales.

Despite the wealth of information available, gaps do exist. For example, perceptions of land owners and advisors (captured via questionnaires) on the flexibility of scheme design or the ability of schemes to accommodate long-term change (i.e. from invasive species or the greater risks posed by flooding) are currently not routinely captured but are required to meet our monitoring requirements (adaptation indicators I2 and I3). Other gaps relate to the issue of scale: for example, at the national-scale, we are able to make inferences about habitat fragmentation but the extent (and opportunities) for improving functional connectivity of the landscape is not captured in detail at the local or farm-scales. Therefore, a farm-level assessment that takes into account habitat fragmentation and improving connectivity is required for monitoring. Other gaps are also evident at present, particularly for those indicators that relate to the catchment/landscape scale (e.g. adaptation indicator G1 – water quality). For example, FEPs are designed to capture information and data at the agreement/farm level and whilst they include some information about the landscape context they may lack sufficient information about off-site impacts (e.g. diffuse pollution causing water quality issues) to meet our needs for monitoring purposes.

Taken in combination, the existing data and proposed datasets that are needed to facilitate monitoring, as described above, will provide the necessary evidence to undertake monitoring of agri-environment schemes at the farm-scale.

5.2. How do we measure change and what does success look like?

Alongside the datasets that provide a basis for identifying change(s) or trends, in order to develop a monitoring framework we also need to be able to effectively measure change and identify a set of success criteria that allow us to report on progress.

As part of the (national-scale) baseline assessment, a number of metrics that may be used to measure change have been produced which directly contribute to the proposed monitoring framework. Indeed, many of these metrics may be used for ground-truthing national-scale trends identified in the baseline assessment. For example, the current extent of priority habitat and coverage by maintenance and restoration options that affect condition or the proximity of newly created habitat to existing core sites; over time we are therefore able to repeat these analyses and compare changes to develop a long-term record.

Measuring change also refers to the type of data collection that is required (e.g. field surveys by Natural England advisors or a third party, or questionnaires with land managers or secondary data collection) as this will need to be appropriate to both the question being answered and the data being collected. Further, the frequency of monitoring is also an important consideration when developing any form of monitoring framework. In many cases, there are likely to be considerable advantages (e.g. ensuring that option prescriptions are being met from the outset) to undertaking monitoring at the start and at the end of agreements (i.e. to determine their effectiveness). In other instances, perhaps at the national-scale where data availability and data updates are infrequent (e.g. changes to species' ranges), the selected monitoring frequency will need to reflect this and/or other drivers (i.e. changes in policy that instigate, or negate, more/less monitoring).

Indicators of success are also required as a check of progress against time. Indicators of success are firmly embedded within existing monitoring of ES schemes where they are used to describe successful management in a way that can be recognised by both the agreement holder and the Advisor (Natural England, 2013c). For example, in the case of HLS, agreements are established for 10 years and the indicators of success (e.g. the condition of priority habitat within the holding will improve over time) enables progress to be made towards the desired objective that may be tracked over time. Consequently, in a similar vein, a set of indicators of success, or success criteria, should be embedded within the proposed monitoring framework to help to describe successful progress and to enable effective reporting. Table 5-2 lists each of the indicators, identifies how each can be measured and recommends associated indicators of success.

Table 5-2 Success criteria and measurement at the national and farm-scales

Adaptation indicator	Success criteria	Measurement
A1. Maintenance and restoration options will be coincident with priority habitats **A2. What is the condition of priority habitats managed under agri-environment schemes?**	National-scale (baseline assessment) Proportion of eligible priority habitat under appropriate options is greater than proportion of total eligible area under any option Farm-scale Proportion of priority habitat in good condition increases over time	National-scale (baseline assessment) -% of priority habitat that covered by appropriate options -% of all eligible land (UAA/RLR) covered by any option -% of SSSI covered by appropriate options Farm-scale % PH area assessed (during field survey) as in good condition.

Adaptation indicator	Success criteria	Measurement
A3. Agri-environment schemes will support SSSIs	See above	See above
A4. Restoration and maintenance options will support highly sensitive habitats **A5. Creation options will concentrate on those habitats most sensitive to climate change (to compensate for potential losses)**	National-scale (baseline assessment) -Total area of sensitive habitat types under appropriate options will increase over time -Proportion of sensitive habitat under appropriate restoration and maintenance options is greater than proportion of less sensitive habitats under appropriate restoration and maintenance options. Farm-scale -Uptake of creation options for highly sensitive habitat is greater than uptake of less sensitive habitat types.	National-scale (baseline assessment) % of total eligible area (UAA/RLR) of each priority habitat type under appropriate options (higher sensitivity habitats should have a greater % of total area under options than lower sensitivity habitats) Farm-scale -Field surveys indicate the presence of defined features that provide improved heterogeneity -% of agreements with these features increases over time.
A6. Uptake will create shade for rivers where this is a priority for the freshwater habitat.	Farm-scale -Total (canopy) area of new trees planted along watercourses will increase over time -Area of riparian habitat lacking shade decreases.	Farm-scale -Total (canopy) area of new trees planted within 10m of river bank -Average gap (in metres) between trees or hedgerows on riparian stretches.
B1. Creation options will reduce fragmentation **B2. Restoration options will support the reduction of fragmentation**	National-scale (baseline assessment) Proportion of habitat creation and restoration options in the high fragmentation band is greater than for non-fragmentation bands. Farm-scale Habitat creation provides new habitat of sufficient quality to reduce fragmentation	National-scale (baseline assessment) -% of total eligible area (UAA/RLR) in each fragmentation band covered by creation options -% of total eligible area (UAA/RLR) in each fragmentation band covered by restoration options Farm-scale Field survey assessment of created habitat quality
C1. Creation, restoration and maintenance of habitats will be focused on refugia	National-scale (baseline assessment) Total area of land under appropriate restoration, maintenance and creation options within areas of high refugium potential scores should increase over time Farm-scale Features identified on-farm as providing potential refugia are protected	National-scale (baseline assessment) Total area of appropriate restoration, maintenance and creation options within areas of high refugium potential scores Farm-scale % of eligible land (UAA/RLR) in each 10km grid covered by appropriate restoration, maintenance and creation options (grids with higher refugium potential scores should have a greater proportion of options in them)
D1. Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions	National-scale (baseline assessment) Total area of appropriate options increases within areas of projected future species ranges Farm-scale The number of agreements containing management designed for new arrivals increases	National-scale (baseline assessment) Total area of appropriate restoration, maintenance and creation options within areas of projected future species ranges Farm-scale -Total number of agreements containing management designed for new arrivals vs those that do not -% of agreements containing appropriate management designed for new arrival species
E1. Creation and restoration options will be	National-scale (baseline assessment)	National-scale (baseline assessment)

Adaptation indicator	Success criteria	Measurement
focused within areas supporting the Outcome 1D objective	Uptake of appropriate options is more concentrated within Outcome 1D potential areas than outside. Farm-scale Habitat creation provides new habitat of sufficient quality to contribute to Outcome 1D.	Total area of habitat creation and restoration within Outcome 1D potential areas Farm-scale Use RAG assessment: Red= habitat creation of poor quality and not linked to any wider ecosystem restoration plans. Amber= Restoration is linked to a wider (landscape scale) ecosystem plan but habitat is of poor quality; Green= New quality habitat is successfully created and links to wider (landscape scale) ecosystem restoration plans.
F1. Creation options around existing semi-natural areas will create larger conservation sites	National-scale (baseline assessment) The size of habitat patches should increase over time Farm-scale Average distance between smaller habitat patches and creation options decreases over time	National-scale (baseline assessment) Total area of habitat patches by semi-natural habitat type Farm-scale Average distance between smaller habitat patches and creation options
F2. Creation options increase the topographic heterogeneity of habitats	National-scale (baseline assessment) A mixture of priority habitats are created Farm-scale Proportion of agreements with Green RAG status increase over time	National-scale (baseline assessment) Total area of different priority habitat created. % of created habitat covered by individual options. Farm-scale Use RAG assessment to determine the degree of heterogeneity on-farm: Red= All habitats uniform; Amber= Some habitats uniform, Green= Full range of variation within habitats.
G1. Matrix options for soil protection will be focussed in Water Quality Priority Areas	National-scale (baseline assessment) Proportion of eligible land within Water Quality Priority Areas with relevant option uptake is greater than the proportion of eligible land outside WQPAs with uptake of the same options. Farm-scale The effectiveness of option placement (for the benefit of water quality) increases over time	National-scale (baseline assessment) % coverage (and total area) of appropriate options within WQPAs (and nationally for comparison). Farm-scale Use RAG assessment to determine the effectiveness of option placement and its contribution towards improvements in water quality: Red = ineffective, Amber= partially effective, Green= effective.
G2. There will be a greater concentration of options within flood prone areas to reduce flood risk	Farm-scale The effectiveness of interventions increases over time.	Farm-scale Use RAG assessment: Red= No options are present that reduce flood risk on, or outside of, the farm; Amber= Some options are present that reduce flood risk but more could be done; Green= all appropriate options are present.
G3. Agri-environment schemes will support the objectives of the Woodlands for Water programme	Farm-scale Total (canopy) area of new trees planted along watercourses will increase over time.	Farm-scale Total (canopy) area of new trees planted within 10 m of river bank. (along riparian stretches at risk (as defined by Keeping Rivers Cool dataset)
H1. Agri-environment schemes contribute to the storage and sequestration of carbon	National-scale (baseline assessment) The area of appropriate options on peat soils increases over time Farm-scale Evidence of improvements in the condition of peat soils over time	National-scale (baseline assessment) % of peat soils covered by appropriate options Farm-scale Condition of peat soils

Adaptation indicator	Success criteria	Measurement
I1. Adaptation in the natural environment will be consistent with agricultural adaptation.	National-scale (baseline assessment) Creation options are targeted towards the lower quality grade land. Farm-scale Increasing proportion of responses to farmer attitude surveys indicate land given over to habitat creation was of low agronomic value.	National-scale (baseline assessment) Proportion of ALC grade 4&5 land covered by creation options greater than proportions for 1-3. Farm-scale Quality of soil for farming prior to habitat creation
I2. Options will be implemented in a flexible way to facilitate adaptive management	National-scale (baseline assessment) Scheme design increasingly facilitates environmental change Farm-scale Proportion of responses indicating positive response ('about right') increases (Land manager perceptions' about the opportunities to adapt existing prescriptions to meet variable conditions).	National-scale (baseline assessment) Use RAG assessment: Red= scheme design does not enable change to be accommodated; Amber= limited change is able to be accommodated; Green= change is fully accommodated. Farm-scale Questionnaires with land managers; positive responses increases over time.
I3. Agri-environment options will accommodate change where appropriate	National-scale (baseline assessment) Scheme design increasingly facilitates environmental change. Farm-scale Agreement design including option choice and prescription setting increasingly accommodates change.	National-scale (baseline assessment) Use RAG assessment: Red= scheme design does not enable change to be accommodated; Amber= limited change is able to be accommodated; Green= change is fully accommodated. Farm-scale Use RAG assessment of questionnaire responses.

5.3. Results: Proposed monitoring framework at the farm-scale

Table 5-3 (overleaf) outlines the proposed monitoring framework. The monitoring framework has been arranged such that its development is logical and the continuity between the NAP objectives, adaptation principles, adaptation indicators and questions at both the national and farm-scales is provided. The framework as presented is not intended to be used in its current form by Advisors and/or land managers. It is recommended that a simplified version, perhaps that separates the different elements by type (i.e. field survey or questionnaire), is used in discussion with Advisors and/or land managers.

Table 5-3 Proposed (detailed) monitoring framework

NAP objective	Adaptation principle	Scale / Outcome(s)	National: Question(s)	National: Data required / Collection method	National: Monitoring frequency	Farm: Purpose, Process and Monitoring Question(s)	Farm: Data required / Collection method	Farm: Monitoring frequency	Success Criteria	Measurement
Building Ecological Resilience	The most important sites for biodiversity will be protected	A1. Maintenance and restoration options will be coincident with priority habitats A2. Priority habitats will be in better condition within areas managed under agri-environment schemes A3. Agri-environment schemes will support SSSIs Objectives Priority habitat and SSSIs are in optimum condition	A1. What is the proportion and total area of priority habitat covered by options that support the maintenance and restoration of habitats? A2. What is the condition of priority habitats managed under agri-environment schemes? A3 What is the proportion and total area of SSSIs covered by maintenance and restoration options?	Priority Habitat Inventory and SSSI units (in GIS format). Note: SSSI condition is currently captured using the Common Standards Monitoring (CSM) programme by Natural England, therefore no additional recommendation to collect data has been made here. A1. Only maintenance and restoration options that focus on core habitat are required. There are 34 relevant options, including Woodland Management and Woodland Restoration Grants, identified using the Excel tool. A3. Only maintenance and restoration options that focus on core habitat creation are required. There are 34 relevant options, including Woodland Management and Woodland Restoration Grants, identified using the Excel tool. No primary data collection is required.	Repeatable as required or as data is updated. Suggested frequency: 2 years	The purpose of monitoring at the farm-scale is twofold. Firstly, using existing databases (BEHTA and FEP) to ground truth the baseline assessment; and secondly, to use monitoring to assess change over time. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by baseline assessment) b. What priority habitat(s) are located on-farm? c. What is the total area covered by each priority habitat? d. What is the proportion of these priority habitat(s) covered by appropriate options (i.e. those that support the maintenance and restoration of habitats)? e. What is the condition of these priority habitats? (Note: for SSSIs use Integrated Site Assessments (ISAs), where available, whilst for non-SSSI habitats that are priority habitats use FEP) f. Are any of these priority habitats impacted by off-site impacts (i.e. diffuse pollution, water quality issues)? g. Is this site a SSSI? If yes, is the site condition known to be negatively affected by off-site impacts? h. Is there agri-environment management in place (perhaps in a separate agreement) to reduce that off-site impact? The analysis should then compare findings from questions a to d against those from the baseline assessment: • Are all priority habitats identified on-farm included in the Priority Habitat Inventory for this area? • Is the total area of priority habitat on-farm similar to that as mapped by the Priority Habitat Inventory? Where are the differences? • Have the impacts of any off-site drivers been addressed? • Are the right option(s) and prescription on the priority habitat (if present) on the site? Note: Questions f to h are intended to provide information about the wider environmental context of the site.	Data: • For agreement-level information, existing databases (BEHTA and FEP) • Site mapping (i.e. location of priority habitats) provided by Webmap Recommended collection method: • Field survey to be (integrated as part of whole farm monitoring programme) • To include survey of farmers' attitudes	At the start of the agreement and at the end of the agreement to determine effectiveness.	National Proportion of eligible priority habitat under appropriate options is greater than total eligible area (of UAA/RLR) under any option Farm Proportion of priority habitat in good condition increases over time	National % of priority habitat that covered by appropriate options % of all UAA/RLR covered by any option % of SSSI covered by appropriate options Farm % PH area assessed (during field survey) as in good condition.
Building Ecological Resilience	Non-climatic adverse pressures will be reduced	B3. Creation options will reduce fragmentation B2. Restoration options will support the reduction of fragmentation Objective Habitat will be created to reduce the fragmentation of existing patches and quality will be improved	What is the proportion and total area of appropriate creation options in each fragmentation buffer?	NBCCVM fragmentation grids at 200m x 200m resolution (in GIS format). B3. Only creation options that focus on core habitat are required. There are 13 relevant options, including Woodland Creation Grants, identified using the Excel tool. B2. Only restoration options that focus on core habitat are required. There are seven relevant options, identified using the Excel tool. No primary data collection is required.	Repeatable as required or as data is updated. Suggested frequency: 2 years	The purpose of monitoring at the farm-scale is threefold. Firstly, using existing databases (BEHTA and FEP) to ground truth the baseline assessment; Secondly, to ground truth the underlying spatial data (NBCCVM fragmentation grids) at the farm-scale; and thirdly, to use monitoring to assess change over time. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by baseline assessment) b. Identify the main priority habitats and smaller habitat patches on farm; Using NBCCVM fragmentation maps (for individual habitat groups, depending upon the habitat types present on-farm) in conjunction with background mapping (i.e. aerial photographs) to answer the following questions: c. Are the habitats identified with high fragmentation, highly fragmented? d. In areas identified with High fragmentation, are agri-environment options improving connectivity? What evidence is there for this? e. What site-level management could be utilised to improve habitat connectivity within areas of High fragmentation (i.e. low connectivity)? At the end of the agreement only: f. Has the habitat creation/restoration been successful? g. Is the new habitat of the intended quality (as set out in the FEP)? h. If no, what else could be done? Note: at this scale, creation and restoration options should be considered.	Data: • For agreement-level information, existing databases (BEHTA, FEP and/or local record centre data, if available) • Site mapping (i.e. NBCCVM fragmentation maps). These maps would need to be incorporated into the existing Webmap service to enable Advisors to view/print mapping as appropriate Recommended collection method: • Field survey to be integrated as part of whole farm monitoring programme)	At the start of the agreement and at the end of the agreement to determine effectiveness.	National Proportion of habitat creation and restoration in the high fragmentation band is greater than for non-fragmentation bands. Farm Habitat creation provides new habitat of sufficient quality to reduce fragmentation	National % of total eligible area (UAA/RLR) in each fragmentation band covered by creation options % of total eligible area (UAA/RLR) in each fragmentation band covered by restoration options Farm Field survey assessment of created habitat quality

NAP objective	Adaptation principle	Scale Outcome(s)	National			Farm			Success Criteria	Measurement
			Question(s)	Data required / Collection method	Monitoring frequency	Purpose, Process and Monitoring Question(s)	Data required / Collection method	Monitoring frequency		
Building Ecological Resilience	Action should focus on areas particularly vulnerable to climate change	A4. Restoration and maintenance options will support highly sensitive habitats A5. Creation options will concentrate on those habitats most sensitive to climate change (to compensate for potential losses) <u>Objectives</u> Habitats highly sensitive to climate change will be restored and maintained to improve their resilience. Sensitive habitats will be created to offset potential losses to climate change	A4. Of habitats with High, Medium or Low (and 1-5) sensitivities, what is the proportion under appropriate restoration and maintenance options? A5. What is the area of creation option uptake by each sensitivity class? Note: highly sensitive habitats are of particular interest including: saltmarsh, montane habitats, coastal vegetated shingle, sand dunes, lowland raised bog, lowland meadows, reedbed, blanket bog, wet woodland, coastal grazing marsh, heathland	Priority habitats and their associated sensitivities to climate change (as indicated in Table C-1) A4. Only restoration and maintenance options that focus on core habitats are required. There are 34 relevant options identified using the Excel tool. Filtered list of appropriate agri-environment options. A5. Only creation options that focus on core habitat creation are required. There are 19 relevant options identified using the Excel tool. No primary data collection is required.	Repeatable as required or as data is updated. Suggested frequency: 2 years	The purpose of monitoring at the farm-scale here is twofold. Firstly, using existing databases (BEHTA and FEP) to ground truth the baseline assessment; and secondly, to use monitoring to assess change over time. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by baseline assessment). Undertake site visits. b. Does the FEP/BEHTA support the presence or creation of features that provide improved heterogeneity (and therefore reduce sensitivity)? c. For each priority habitat with a high sensitivity in turn, are any of the impacts identified in the Natural England and RSPB Adaptation Manual (2014) likely to pose a threat? d. What action, if any, is currently being undertaken to address these threats or create compensatory habitat elsewhere? e. If no action is taking place, what else could be done?	Data: • For agreement-level information, existing databases (BEHTA and FEP) Recommended collection method: • Field surveys as part of whole farm monitoring programme	At the start of the agreement and at the end of the agreement to determine effectiveness.	<u>National</u> Total area of sensitive habitat types under appropriate options will increase over time Proportion of sensitive habitat under restoration and maintenance options is greater than proportion of less sensitive habitats under appropriate restoration and maintenance options <u>Farm</u> Uptake of creation options for highly sensitive habitat is greater than uptake of less sensitive habitat types.	<u>National</u> % of total eligible area (UAA/RLR) of each priority habitat type under appropriate options (higher sensitivity habitats should have a greater % of total area under options than lower sensitivity habitats) <u>Farm</u> Field surveys indicate the presence of defined features that provide improved heterogeneity % of agreements with these features increases over time.
Building Ecological Resilience	Action should focus on areas likely to remain less impacted by climate change	C1. Creation, restoration and maintenance of habitats will be focussed on refugia <u>Objective</u> Areas projected to remain relatively unaffected by climate change should be protected	What is the area of appropriate creation, maintenance or restoration options in areas of high and low refugia?	Maps depicting refugium potential scores (where, 0=low refugium potential, 1=high refugium potential) for England at 10km resolution (or greater). Not required for individual species. Only options that focus on core creation, maintenance and restoration of habitats are required. There are 53 relevant options identified using the Excel tool. No primary data collection required.	Repeatable as required or as data is updated or if new data becomes available. Suggested frequency: 5 years	The purpose of monitoring at the farm-scale here is to identify areas of refugia, rather than ground-truthing the baseline assessment. Use field surveys to identify potential refugia sites that are present on-farm. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by the baseline assessment). b. To what extent do the habitat(s) present on farm have similar (or different): • Aspect (including north facing slopes)? • Shading? • Vegetation of similar heights? • Soil type(s)? • Springs? • High water or general evidence of persistent topographic wetness? c. Where there is variety in existing habitat patches, does current management protect this variety? Where it is limited, do options increase the variety within habitats? d. If no action is taking place, could changing management serve to protect and/or extend habitat onto these features?	Data: • Outputs from surveys Recommended collection method: • Field surveys as part of whole farm monitoring programme	At the start of the agreement and at the end of the agreement to determine effectiveness.	<u>National</u> Total area of land under appropriate restoration, maintenance and creation options within areas of high refugium potential scores should increase over time <u>Farm</u> Features identified on-farm as providing potential refugia are protected	<u>National</u> Total area of appropriate restoration, maintenance and creation options within areas of high refugium potential scores <u>Farm</u> % of eligible land (UAA/RLR) in each 10km grid covered by appropriate restoration, maintenance and creation options (grids with higher refugium potential scores should have a greater proportion of options in them)
Valuing the wider adaptation benefits the natural environment can deliver	Identify opportunities for Ecosystem-based Adaptation	G1. Matrix options for soil protection will be focussed in Water Quality Priority Areas *<u>Objective</u>* Restoration of the natural environment should be used to promote water quality	What is the proportion and total area of Water Quality Priority Areas covered by appropriate matrix options?	Water Quality Priority Areas (in GIS format). Only those options focussing on maintenance, restoration and creation of habitats are required. There are 112 relevant options identified using the Excel tool. No primary data collection required.	Repeatable as required or as data is updated. Suggested frequency: 5 years	The purpose of monitoring at the farm level is to identify the contribution (if any) of options to deliver improvements in water quality and to identify any opportunities. Process:: a) Identify a random sample of appropriate agreements (i.e. as evidenced by the baseline assessment) b) To what extent do the options currently used on farm provide (or contribute to) improvements in water quality (using FEP/BEHTA)? c) (In discussion with the land manager), could existing option placement be changed to improve water quality? d) Could additional options be used to contribute to improvements in water quality?	Data: • Outputs from surveys Recommended collection method: • Field survey as part of whole farm monitoring programme	At the start of the agreement and at the end of the agreement to determine effectiveness.	<u>National</u> Proportion of eligible land within WQPAs with relevant option uptake is greater than proportion of eligible land outside WQPAs with uptake of the same options. <u>Farm</u> The effectiveness of option placement (for the benefit of water quality) increases over time	<u>National</u> % coverage (and total area) of appropriate options within WQPAs (and nationally for comparison) <u>Farm</u> Use RAG assessment to determine the effectiveness of option placement and its contribution towards improvements in water quality (Red = ineffective,

NAP objective	Adaptation principle	Scale / Outcome(s)	National: Question(s)	National: Data required / Collection method	National: Monitoring frequency	Farm: Purpose, Process and Monitoring Question(s)	Farm: Data required / Collection method	Farm: Monitoring frequency	Success Criteria	Measurement
										Amber= partially effective, Green= effective)
Preparing for and accommodating inevitable change	Improving the flexibility of responses	I2. Flexibility in implementation of options will allow for more adaptive management <u>Objective</u> Agreements , including option deployment, and prescription setting should promote flexibility and encourage innovation to enable adaptation indicators to be met in the face of increasing climatic variation	Does the scheme design and architecture enable environmental change to be accommodated?	Existing scheme design and operation guidance. No primary data collection required.	Synchronised with scheme launch and review	The purpose of monitoring at the farm level is to better understand agreement holder perspectives on flexibility using questionnaires. Process: a. Identify a random sample of appropriate agreements b. Have you been able/unable to meet positive management requirements and/or dates, within the constraints provided by the weather and ground conditions? If unable, why? c. Have you been able to achieve favourable condition of habitat? d. Have the indicators of success been met? e. For how many options (if at all) have you had to seek amendments to option prescriptions to allow for changing conditions? (for example, increased waterlogging in winter) f. In your opinion, does the scheme provide too little/too much flexibility/about right in meeting the environmental objectives?	Data: • Outputs from surveys Recommended collection method: • Survey of farmer attitudes, integrated as part of whole farm monitoring programme	At the start of the agreement and at the end of the agreement to determine effectiveness.	<u>National</u> Scheme design increasingly facilitates environmental change <u>Farm</u> Proportion of responses indicating positive response ('about right') increases (Land manager perceptions' about the opportunities to adapt existing prescriptions to meet variable conditions).	<u>National</u> Use RAG assessment (i.e. Red= scheme design does not enable change to be accommodated; Amber= limited change is able to be accommodated; Green= change is fully accommodated) <u>Farm</u> Questionnaires with land managers; positive responses increases over time
Preparing for and accommodating inevitable change	Environmental goals and targeting will reflect environmental change	I3. Agri-environment options which accommodate change will support adaptation <u>Objective</u> Agreements, including objective setting, option deployment, and prescription setting should accommodate environmental change where inevitable	Does the scheme design and architecture enable environmental change to be accommodated?	Existing scheme design and operation guidance. No primary data collection required.	Synchronised with scheme launch and review	The purpose of monitoring at the farm-scale is to assess if and how longer-term changes are accommodated in agreements. Process: a. Select a sample of agreements identified as containing habitats/features sensitive to climate change impacts (i.e. coastal, wetlands or uplands). b. Desk assessment of agreements: • For <u>woodlands</u>: i. Is the vulnerability to invasive species, pest and/or disease accounted for? (e.g. avoiding single-species planting; diversifying existing species-poor woodland etc.) ii. Are increases in the frequency of extreme events (high winds, temperature, moisture or drought) factored into management decisions? • For <u>coastal and fluvial</u> habitats: i. Does the agreement consider the impacts of sea level rise? i.e. habitat shift, saline intrusion, managed realignment ii. Does the agreement consider the impacts of changing river conditions? i.e. changes to river courses, flow regime, temperature, higher winter water table or drought iii. Does the agreement consider increased risks posed by flooding (in terms of depth and frequency)? • For <u>heathland and moorland</u> habitats: i. What provision is made to address increase in temperature? i.e. wildfire risk, increasing visitor numbers, drought, longer growing season, lower water table ii. Does the agreement consider risks posed by extreme events? i.e. storms, high winds, summer and winter flooding • For <u>wetland</u> habitats: i. Does the agreement allow for change in water levels? i.e. winter flooding, summer water availability ii. Does the agreement consider risks posed by extreme events? i.e. soil run-off and nutrient enrichment to the catchment, increased temperature, fewer frost days	Data: • Outputs from surveys Recommended collection method: • Desk assessment • Land manager survey, integrated as part of whole farm monitoring programme • Survey of advisors.	At the start of the agreement and agreements in their final year or at the end of the agreement to determine effectiveness.	<u>National</u> Scheme design increasingly facilitates environmental change <u>Farm</u> Agreement design including option choice and prescription setting increasingly accommodates change	<u>National</u> Use RAG assessment (i.e. Red= scheme design does not enable change to be accommodated; Amber= limited change is able to be accommodated; Green= change is fully accommodated) <u>Farm</u> Use RAG assessment of questionnaire responses

NAP objective	Adaptation principle	Scale / Outcome(s)	National			Farm			Success Criteria	Measurement
			Question(s)	Data required / Collection method	Monitoring frequency	Purpose, Process and Monitoring Question(s)	Data required / Collection method	Monitoring frequency		
						iii. Does the agreement consider risks of seal level rise? i.e. saline intrusion, increased frequency of saline intrusion c. In respect of any of the broad habitat types listed above, where management has been put in place, what has the impact been? d. Question for Advisor: did you take into account longer-term changes (in setting objectives) to habitats in setting objectives and species (e.g. species movements including new species arrival and loss of existing species, changes to community composition and structure and the timing of events e.g. budburst) or the environment (e.g. sea level rise, changes in flows and water availability)? If so, what do you take account of? e. If you do not take longer-term changes into account, why do you not do this? e.g. no impacts observed, short-term duration of agreement, uncertainty on direction of change or something else. Questions to be answered by the land manager: a. Do you think about the impacts of longer-term changes (i.e. from climate change) to your land? What concerns you the most? b. What management have you put in place to reduce the impact of these changes? For example building resilience or changing approaches and objectives e.g. new or different crops, changed operations/machinery, timing of operations? c. Do you keep records of changing conditions? For example, the first leaf drop in autumn or when you hear the first calling of cuckoos in Spring? Would you be interested in recording/sharing this information? d. What extra information would help you to reduce threats from climate change? i.e. more/less water, increase in temperature				
Preparing for and accommodating inevitable change	Environmental goals and targeting will reflect environmental change	D1. Agri-environment options will be coincident with priority areas of different taxa	What is the total area of appropriate options in relation to the priority areas of future ranges of taxa?	Maps depicting priority areas of future ranges of different taxa for England at 10km resolution (or greater). Not required for individual species. Only options that focus on core creation, maintenance and restoration of habitats are required. There are 53 relevant options identified using the Excel tool. No primary data collection required.	Repeatable as required or as data is updated or if new data becomes available. Suggested frequency: 5 years	The purpose of monitoring at the farm-scale here is to identify where agreements contain management designed to allow for species persistence and arrival rather than ground-truthing the baseline assessment. Process: a. Identify future ranges of priority species (using baseline assessment) b. For individual agreements, identify priority species for agri-environment that are on the leading edges of their current range at the site c. Is appropriate management in place (i.e. the creation or restoration of features) for species projected to expand within/into the area? d. Has specific consideration to these species been made when setting up the agreement? e. Is the current management achieving suitable habitat to support the new species?	Data: • Species current and projected distribution data FEP/BEHTA • Agreement information Recommended collection method: • Desk assessment of agreement documentation. • Field survey	At start of agreement	National Total area of appropriate options increases within areas of project future species ranges Farm The number of agreements containing management designed for new arrivals increases	National Total area of appropriate restoration, maintenance and creation options within areas of projected future species ranges Farm Total number of agreements containing management designed for new arrivals vs those that do not % of agreements containing appropriate management designed for new arrival species
Building Ecological Resilience	Restore degraded ecosystems	E1. Creation and restoration options will be focused within the Outcome 1D potential areas Objective Creation and restoration should be focused in those locations with the greatest potential for environmental gain	What is the proportion and total area of Outcome 1D potential areas covered by creation and restoration options?	Output 1D habitat potential maps (in GIS format) for broad priority habitat groups Only options that focus on core habitat creation or restoration are required. There are 20 relevant options identified using the Excel tool. No primary data collection required.	Repeatable as required or as data is updated. Suggested frequency: 5 years	The purpose of monitoring at the farm-scale is twofold. Firstly, to ground-truth the baseline assessment and, secondly, to monitor change over time. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by the baseline assessment) b. What proportion of 1D potential areas are covered by appropriate options? c. Is the management achieving effective ecosystem restoration? If not, what else could be done?	Data: • 1D (Habitat potential) data layers • FEP/Agreement documentation Recommended collection method: • Desk assessment • Field monitoring, integrated as part of whole farm monitoring programme.	At the start of the agreement and agreements in their final year or at the end of the agreement.	National Uptake of appropriate options is more concentrated within Outcome 1D potential areas than outside Farm Habitat creation provides new habitat of sufficient quality to contribute to Outcome 1D.	National Total area of habitat creation and restoration within Outcome 1D potential areas Farm Use RAG assessment (Red= habitat creation of poor quality and not linked to any wider ecosystem restoration plans. Amber= Restoration is linked to a wider (landscape scale) ecosystem plan but habitat is of poor quality; Green= New quality habitat is successfully created and

NAP objective	Adaptation principle	Scale / Outcome(s)	National: Question(s)	National: Data required / Collection method	National: Monitoring frequency	Farm: Purpose, Process and Monitoring Question(s)	Farm: Data required / Collection method	Farm: Monitoring frequency	Success Criteria	Measurement
										links to wider (landscape scale) ecosystem restoration plans.
Building Ecological Resilience	Increase the heterogeneity of patches	F2. Creation options increase the topographic heterogeneity of habitats Objective The topographic heterogeneity covered by semi-natural habitat is increased by habitat creation	What is the mixture of priority habitat(s) under appropriate creation options? Process: a) Identify all priority habitats within areas under appropriate creation options. Output as breakdown of creation option coverage by priority habitat.	Priority Habitat Inventory (in GIS format). Only those options that support habitat creation are required. There are 13 relevant options identified using the Excel tool. No primary data collection required.	Repeatable as required or as data is updated. Suggested frequency: 5 years	The purpose of monitoring at the farm-scale here is twofold. Firstly, to ground-truth the baseline assessment and, secondly, to monitoring change over time. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by the baseline assessment) b. Identify the areas of pre-existing habitat on farm (including areas not recorded on the PH Inventory) c. Identify how the agreement improves and/or creates new habitat d. Assess the extent to which the agreement has extended the range of heterogeneity on the holding.	Data: • FEP • BEHTA Recommended collection method: • Field surveys by Advisors as part of whole farm monitoring programme	At the start of the agreement and agreements in their final year or at the end of the agreement.	National A mixture of priority habitats are created Farm Proportion of agreements with Green RAG status increase over time	National Total area of different priority habitat created. % of created habitat covered by individual options. Farm Use RAG assessment to determine the degree of heterogeneity on-farm (Red= All habitats uniform; Amber= Some habitats uniform, Green= Full range of variation within habitats)
Building Ecological Resilience	Increase the size of existing patches	F1. Creation options around existing habitats will support adaptation Objective Habitat creation will increase the size of existing habitat patches	What is the proportion and total area of creation options abutting existing habitat and within 0.5km, <1km and >1km of existing priority habitats?	Priority Habitat Inventory (in GIS format). Only those options that focus on core habitat creation are required. There are 17 options, including Woodland Creation Grants, identified using the Excel tool. No primary data collection required.	Repeatable as required or as data is updated. Suggested frequency: 2-3 years	The purpose of monitoring at the local scale is to ground-truth the baseline assessment and monitor change over time. Process: a. Identify a sample of appropriate agreements (i.e. as evidenced by baseline assessment) b. Identify the pre-agreement average size of habitat patch on the holding. c. Identify the areas of created habitat on farm and decide whether these extend existing patches (including close proximity) or create new ones. d. Identify the post-agreement average size of habitat patch on the holding. Identify any missed opportunities to create larger patches through additional habitat creation or closer proximity.	Data: • Outputs from surveys Recommended collection method: • Field surveys by Advisors as part of whole farm monitoring programme	At the start of the agreement and agreements in their final year or at the end of the agreement.	National The size of habitat patches should increase over time Farm Average distance between smaller habitat patches and creation options decreases over time	National Total area of habitat patches by semi-natural habitat type Farm Average distance between smaller habitat patches and creation options
Valuing the wider adaptation benefits the natural environment can deliver	Identify opportunities for Ecosystem-based Adaptation	G2. There will be a greater concentration of options within flood prone areas to reduce flood risk Objective Creation and restoration of the natural environment should be used to alleviate the threat of flooding	Not applicable.			The purpose of monitoring at the local scale is to improve the resilience of on-farm (and catchment) to flooding. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by baseline assessment) b. Is the location of the option(s) appropriate to reducing flood risk on-farm? c. Is the location of the options(s) appropriate to reducing flood risk outside of the farm? d. What other measures (if any) could be utilised to reduce vulnerability?	Data: • Outputs from surveys Recommended collection method: • Field surveys by Advisors as part of whole farm monitoring programme	At the start of the agreement and agreements in their final year or at the end of the agreement.	Farm The effectiveness of interventions increases over time.	Farm Use RAG assessment (Red= No options are present that reduce flood risk on, or outside of, the farm; Amber= Some options are present that reduce flood risk but more could be done; Green= all appropriate options are present)
Valuing the wider adaptation benefits the natural environment can deliver	Identify opportunities for Ecosystem-based Adaptation	A6. Uptake will create shade for rivers where this is a priority for the freshwater habitat. Objective Tree planting / hedge management will provide shade in livestock areas where existing shade is lacking.	Not applicable.			The purpose of monitoring at the local scale is to identify features that support riverine shading. Process: a. Identify a random sample of appropriate agreements that have a river (or rivers) running through their agreement area b. Is there evidence of tree or hedgerow planting or allowing trees to grow higher in more vulnerable areas? What existing options have been used? c. Estimate the potential additional length of river shaded (assuming all planting grows to maturity). Also estimate the total canopy shade provided by new trees. d. What additional options (if any) could be utilised to improve riverine shading within the agreement area?	Data: • 'Keeping Rivers Cool' dataset Recommended collection method: • Field surveys by Advisors as part of whole farm monitoring programme	At the start of the agreement and agreements in their final year or at the end of the agreement.	Farm Total (canopy) area of new trees planted along watercourses will increase over time	Farm Total (canopy) area of new trees planted within 10m of river bank (along riparian stretches at risk as defined by Keeping Rivers Cool dataset)

NAP objective	Adaptation principle	Scale / Outcome(s)	National: Question(s)	National: Data required / Collection method	National: Monitoring frequency	Farm: Purpose, Process and Monitoring Question(s)	Farm: Data required / Collection method	Farm: Monitoring frequency	Success Criteria	Measurement
Valuing the wider adaptation benefits the natural environment can deliver	Identify opportunities for Ecosystem-based Mitigation	H1. Agri-environment schemes contribute to the storage and sequestration of carbon Objective Mitigation should be promoted by protecting existing carbon stocks on peat soils	What is the proportion (and area) of blanket peat and peat soils with appropriate agri-environment options on?	National Soils map (NatMap vector) in GIS format. Only those options that support the creation, restoration and maintenance of core habitat are required. There are 27 relevant options identified using the Excel tool. No primary data collection required.	Repeatable as required or as data is updated. Suggested frequency: 5 years	The purpose of monitoring at the local scale is to ground-truth the baseline assessment and monitor change over time. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by baseline assessment) b. Identify the location of peat soils that are present on-farm c. What is the condition of these soils? (e.g. approximate vegetation cover as proportion vs bare earth, what is the soil waterlogged?) d. Are there any areas that are not benefitting from restoration?	Data: • Outputs from surveys Recommended collection method: • Field surveys by Advisors as part of whole farm monitoring programme	At the start of the agreement and agreements in their final year or at the end of the agreement.	National The area of appropriate options on peat soils increases over time Farm Evidence of improvements in the condition of peat soils over time	National % of peat soils covered by appropriate options Farm Condition of peat soils
Valuing the wider adaptation benefits the natural environment can deliver	Adaptation for the natural environment will have no net cost to society	I1. Creation options will be targeted to the lowest quality agricultural land	What is the area of core habitat creation options within each Agricultural Land Classification (ALC) grade?	Agricultural Land Classification (ALC) data (in GIS format). Only those options that focus on core habitat creation are required. There are 19 relevant options, including Woodland Creation Grants, identified using the Excel tool. No primary data collection required.	Repeatable as required or as data is updated. Suggested frequency: 5 years	The purpose of monitoring at the local scale is to ground-truth the baseline assessment. Process: a. Identify a random sample of appropriate agreements (i.e. as evidenced by baseline assessment). b. Identify any areas of permanent habitat creation. c. Check ALC grade of soils under these creation options. d. Consult land manager for their assessment of the productive value of the land i.e. how would they rate the land as 1 (Highly productive) to 5 (Least productive). e. From your (land owners') perspective, what is your view of targeting on land that you manage/own?	Data: • Outputs from surveys Recommended collection method: • Desk assessment and questionnaire as part of whole farm monitoring programme	At the start of the agreement and agreements in their final year or at the end of the agreement.	National Creation options are targeted towards the lower quality grade land. Farm Increasing proportion of responses to farmer attitude surveys indicate land given over to habitat creation was of low agronomic value.	National Proportion of ALC grade 4 and 5 land covered by creation options greater than proportions for 1-3 Farm Quality of soil for farming prior to habitat creation

6. Discussion

6.1. Summary

This report represents the first attempt, to our knowledge, to develop a robust methodology and baseline assessment of the ability of agri-environment schemes to deliver climate change adaptation for the natural environment in Europe. It also provides a monitoring framework and national assessment of how the schemes support EbA. Ecosystem-based Mitigation was also considered in relation to carbon storage and sequestration.

Section 6.2 provides tabulated summaries for each adaptation indicator, including data availability, monitoring criteria and an assessment of Natural England's ability to deliver adaptation for each objective; the assessments provided above has been used to inform these summaries. Following this, a summary of the contribution that agri-environment schemes are making (or not) to the adaptation principles previously outlined (Section 2) is provided (Section 6.3), before a set of recommendations are made (Section 6.4).

6.2. Tabulated summaries of findings

Provided in the tables that follow is a synthesis of information gleaned from Sections 1 to 5 for each adaptation indicator.

A. Protecting the most important and vulnerable sites

Indicator A1: Maintenance and restoration options will be coincident with priority habitats

Table 6-1 Summary of findings - Indicator A1

Element	Confidence level	Justification
Justification of adaptation indicator	High	There is a strong evidence base in the scientific literature for the protection of existing important areas for biodiversity being a fundamental first step in adaptation; and strong evidence that 'priority habitats' represent many of the most important areas for biodiversity.
Data		
National	Medium	Accurate geospatial data exists on the location of priority habitats. Available agri-environment schemes data uses parcel centroids, full georeferenced data would improve the analysis.
Farm-scale	High	Existing data from FEP and BEHTA combined with site visit and discussion with land owner(s) will enable an accurate view to be gathered.
Finding		
Combined confidence level	High	The combination of national and farm-scale monitoring will provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	High	Existing targeting to deliver Bio2020 is likely to mean that this outcome will be met.

Protecting existing biodiversity is core to climate change adaptation and within this priority habitats represent a measure of environmental importance. Data exists nationally on the location of priority habitats and whether they fall under agri-environment scheme options. At the farm-scale these measures can be ground-truthed. Due to the alignment of this outcome with those of Bio2020 the success criteria are likely to be met.

Indicator A2: Priority habitats will be in better condition within areas managed under agri-environment schemes

Table 6-2 Summary of findings - Indicator A2

Element	Confidence level	Justification
Justification of adaptation indicator	High	To adequately protect biodiversity, agri-environment scheme options should assess the condition of sites by addressing non-climatic adverse drivers.
Data		
National-scale	Low	Limited availability of data. Priority habitat outside agri-environment schemes is poorly monitored and the condition of priority habitat under agri-environment schemes is not available spatially.
Farm-scale	High	If a full ISA/NVC assessment is conducted the data should be of sufficient quality to make an informed decision.
Finding		
Combined confidence level	Medium	Farm-scale assessment may provide too small a sample to make an informed assessment of this indicator.
Monitoring		
Ability to deliver	High	Existing targeting to deliver Bio2020 is likely to mean that this outcome is met.

The confidence in the desired adaptation indicator is high, and the ability of the scheme to deliver the outcome due to its overlap with Bio2020 targeting is also high. There is less confidence in the ability to monitor progress due to the lack of comprehensive national data (for all habitat types) and the inclusion of many non-agreement farms in the farm-scale monitoring.

Indicator A3: Agri-environment schemes will support SSSIs

Table 6-3 Summary of findings - Indicator A3

Element	Confidence level	Justification
Justification of adaptation indicator	High	The importance of protected areas in delivering adaptation of the natural environment has been demonstrated for species at both the leading and trailing edge of their ranges. Appropriate agri-environment scheme options ensure optimum management of habitats.
Data		
National-scale	Medium	Accurate spatial data exists on the location of SSSIs. Available agri-environment schemes data uses parcel centroids, full georeferenced data would improve the analysis.
Farm-scale	High	Existing data from FEP and BEHTA combined with site visit and discussion with land owner(s) will enable an accurate view to be gathered
Finding		
Combined confidence level	High	The combination of national and farm-scale monitoring will provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	High	Existing targeting to deliver Bio2020 is likely to mean that this outcome will be met.

The protection of SSSIs is a subset of indicator A1. There is increasing evidence that demonstrates the importance of the protected area network in delivering adaptation both for species doing well under climate change and also those that are projected to lose climate space. This benefit goes beyond that delivered by semi-natural habitat, reinforcing the importance of ensuring that the protected area network is under optimum management.

Indicator A4: Restoration and maintenance options will support highly sensitive habitats

Table 6-4 Summary of findings - Indicator A4

Element	Confidence level	Justification
Justification of adaptation indicator	High	The sensitivity of habitats to climate change differs. Those habitats most sensitive are likely to be more vulnerable to the interaction with other non-climatic pressures. The resilience of these habitats should be promoted through appropriate management.
Data		
National-scale	Medium	Accurate geospatial data exists on the location of priority habitats. Available agri-environment scheme data uses parcel centroids, full georeferenced data would help to improve the analysis.
Farm-scale	High	Existing data from FEP and BEHTA combined with site visit and discussion with land owner will enable an accurate view to be gathered.
Finding		
Combined confidence level	High	The combination of national and farm-scale monitoring will provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	Medium	Under the current targeting there is no prioritisation based on sensitivity, the outcome is likely to be partially delivered through the broader focus on priority habitats.

Habitats will differ in their sensitivity to the impact of climate change. Expert judgement based on the published evidence has been used to rank the sensitivity of priority habitats using a 1-5 scale. The location of priority habitats are well mapped, but the agri-environment schemes data is mapped to parcel centroids.

Indicator A5: Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)

Table 6-5 Summary of findings - Indicator A5

Element	Confidence level	Justification
Justification of adaptation indicator	High	The sensitivity of habitats to climate change differs. Those habitats most sensitive are likely to be more vulnerable and be altered or lost. Priority should therefore be given to the creation of highly sensitive habitats to counter any losses.
Data		
National-scale	Low	The resolution of the habitat creation options under ES does not provide sufficient precision to determine which priority habitat is being created.
Farm-scale	High	A review of the prescriptions and indicators of success at the agreement level will determine the priority habitat that is the focus of habitat creation.
Finding		
Combined confidence level	Low	Only farm-scale monitoring will provide an accurate assessment of the delivery of this indicator. This will not provide a national picture by which to assess the delivery of this indicator.
Monitoring		
Ability to deliver	Medium	Under the current targeting there is no prioritisation based on habitat sensitivity to climate change; this outcome is likely to be partially delivered through the broader focus on priority habitats covered by other indicators.

There is a clear logic for seeking to address habitat sensitivity to climate change as part of an adaptation response. Agri-environment schemes are the most obvious and widely available mechanism for addressing sensitivity. Whilst the scope for monitoring appears to be limited at present to the farm-scale, this should also enable a field-level assessment of the quality of the habitat created and its management. Meanwhile, seeking to improve the data available nationally should be a priority. Whilst delivery is not specifically targeted towards habitat sensitivity the impact is likely to be limited which may limit the ability to meet this objective.

Indicator A6: Agri-environment scheme management will create shade for rivers where this is a priority for the freshwater habitat

Table 6-6 Summary of findings - Indicator A6

Element	Confidence level	Justification
Justification of adaptation indicator	Medium	There is increasing evidence (both modelled and empirical) that demonstrates the benefits of tree planting along water courses to cool water temperature.
Data		
National-scale	Low	Underlying spatial data exists to identify catchments where such as approach is warranted. National data on option uptake do not provide the necessary spatial resolution to assess this outcome.
Farm-scale	High	Underlying spatial data exists to identify catchments where such as approach is warranted. The position of planting can be determined through an agreement level review.
Finding		
Combined confidence level	Low	The lack of a national assessment method and lack of coverage of agreements adjacent to watercourses in vulnerable catchments means that an overall assessment of this indicator will be sporadic at best.
Monitoring		
Ability to deliver	Low	It is unlikely that the agri-environment schemes intervention will provide the necessary coverage to significantly influence watercourse temperature. Current targeting is unlikely to lead to significant planting in response to this objective.

There is increasing evidence of the beneficial impact of riparian shading on reducing water temperatures in watercourses, with resulting benefits for a family of species, such as Salmonids. Trees need to be within close proximity of the watercourses. National data is unable to provide the spatial resolution to assess this indicator. Farm-scale monitoring will enable accurate assessment against this indicator but the coverage of agreements in appropriate locations that include tree planting is likely to be low, therefore a comprehensive assessment is unlikely. The current targeting of woodland planting is unlikely to deliver a comprehensive benefit against this target.

B. Reducing fragmentation and enhancing ecological networks

Indicator B1: Creation options will reduce fragmentation

Table 6-7 Summary of findings - Indicator B1

Element	Confidence level	Justification
Justification of adaptation indicator	High	Fragmentation of habitat represents a significant barrier to autonomous adaptation through the prevention of dispersal.
Data		
National-scale	High	The national datasets represent an accurate synthesis of fragmentation enabling accurate targeting. Point centroid data provides sufficient resolution.
Farm-scale	High	Farm-scale assessment of the spatial location and quality of habitat creation will provide ground-truthing.
Finding		

Combined confidence level	High	The combination of national assessment of the spatial creation in relation to fragmentation metrics, combined with ground-truthing farm-scale monitoring will provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	High	Delivery of the recommendations of the Lawton review (see Lawton *et al.,* 2010) are an objective of CS with the appropriate fragmentation data layers informing targeting.

Habitat fragmentation represents a key barrier to the movement of species through landscapes and the resilience of populations in remaining patches. Habitat creation can be spatially targeted to reduce fragmentation and improve the connectivity of landscapes.

Indicator B2: Restoration options will support the reduction of fragmentation

Table 6-8 Summary of findings - Indicator B2

Element	Confidence level	Justification
Justification of adaptation indicator	High	Fragmentation of habitat represents a significant barrier to autonomous adaptation through the prevention of dispersal.
Data		
National-scale	Medium	The national datasets represent an accurate synthesis of fragmentation enabling accurate targeting. The underpinning data on habitat is less reliable due to inconsistency in the definition of degraded habitats, and also the redefinition of restored habitat. Point centroid data provides sufficient resolution.
Farm-scale	High	Farm-scale assessment of the spatial location and quality of habitat creation will provide ground-truthing
Finding		
Combined confidence level	Medium	The combination of national assessment of the spatial creation in relation to fragmentation metrics, combined with ground-truthing farm-scale monitoring should provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	Medium	Delivery of the recommendations of the Lawton review are an objective of CS with the appropriate fragmentation data layers informing targeting. However, this will primarily be associated with habitat creation; habitat restoration is less likely to be considered under the Lawton objective in relation to fragmentation and may be picked up under the broader restoration of habitat targets.

This Indicator should be considered together with B1 to understand the combined impact of restoration and creation options on habitat fragmentation. With the availability of data, potential for farm-scale assessment and integration into targeting, there is potential for agri-environment schemes to make a significant impact on fragmentation and to monitor and assess this impact over time.

Indicator B3: Woodland creation options will help to reduce woodland fragmentation

Table 6-9 Summary of findings - Indicator B3

Element	Confidence level	Justification
Justification of adaptation indicator	High	Fragmentation of habitat represents a significant barrier to autonomous adaptation through the prevention of dispersal.
Data		
National-scale	High	The national dataset on woodland networks represent an accurate synthesis of fragmentation enabling accurate targeting. Point centroid data provides sufficient resolution.
Farm-scale	High	Farm-scale assessment of the spatial location and quality of habitat creation will provide ground-truthing.

Finding		
Combined confidence level	High	The combination of national assessment of the spatial creation in relation to fragmentation metrics, combined with ground-truthing farm-scale monitoring will provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	High	Delivery of the recommendations of the Lawton review is an objective of CS with the appropriate fragmentation data layers informing targeting.

Note, due to the way fragmentation metrics are derived, measures of changes in landscape fragmentation would be problematic (i.e. due to changes in adaptive capacity driven by other factors not linked to agri-environmental management).

Similar comments apply here as to B1. Habitat fragmentation is a significant issue for adaptation, that environmental land management schemes are well placed to address. With reliable data available nationally (and the potential for farm-scale monitoring) this indicator is well-suited to inclusion into a monitoring framework.

Indicator B4: Woodland restoration and maintenance options will support the reduction of woodland fragmentation

Table 6-10 Summary of findings - Indicator B4

Element	Confidence level	Justification
Justification of adaptation indicator	Medium	The effectiveness of maintaining or improving the condition of existing patches on fragmentation is not clear.
Data		
National-scale	High	The national dataset on woodland networks represent an accurate synthesis of fragmentation enabling accurate targeting. Point centroid data provides sufficient resolution.
Farm-scale	High	Farm-scale assessment of the spatial location and quality of habitat creation will provide ground-truthing.
Finding		
Combined confidence level	High	The combination of national assessment of the spatial creation in relation to fragmentation metrics, combined with ground-truthing farm-scale monitoring will provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	Low	The current targeting does not prioritise maintenance and restoration in fragmented networks. The priority given to woodland varies across NCAs.

Maintenance options will not have an impact on fragmentation, but the restoration of degraded patches will. Whether the restoration will lead to a reduction in fragmentation as recorded by the national analysis will depend on the habitat classification prior to restoration, and once the habitat has been restored. The farm-scale assessment will enable ground-truthing both of the quality of the restored habitat but also the issues relating to the national datasets. It is unlikely that the woodland planting prioritisation under CS will provide sufficient direction to deliver this objective.

Indicator B5: Matrix options to restore or create features should be focussed in areas of high fragmentation

Table 6-11 Summary of findings - Indicator B5

Element	Confidence level	Justification
Justification of adaptation indicator	Low	Evidence to support the most effective targeting of matrix options is weak in relation to connectivity and fragmentation.
Data		

National-scale	High	The data is available on fragmentation zones and the distribution of matrix options to undertake this analysis.
Farm-scale	High	The data is available on fragmentation zones and the distribution of matrix options to undertake this analysis.
Finding		
Combined confidence level	High	The combination of national assessment of the spatial creation and restoration in relation to fragmentation metrics, combined with ground-truthing farm-scale monitoring will provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	Low	Currently little targeting of matrix options to areas of high fragmentation. The loss of the Entry Level element of CS means that the area of matrix options is likely to decline, making delivery of this indicator difficult.

The theory is that where habitat creation or restoration is not possible, options that restore or create semi-natural features in the landscape, are a useful 'second-best' for reducing fragmentation. This relies on the notion that linear features and 'stepping stones' facilitate movement of species (as a positive for adaptation), but the evidence is uncertain and there is a risk of facilitating the movement of invasive non-natives. Whilst the theory remains untested there is potential for monitoring which could, in turn, help to refine the theory.

Indicator B6: Creation options are located within 1 km of core areas

Table 6-12 Summary of findings - Indicator B6

Element	Confidence level	Justification
Justification of adaptation indicator	High	Recent evidence suggests that for many species habitat creation within 1 km of existing habitat is optimal.
Data		
National-scale	Medium	Existing agri-environment schemes point data provides a good picture of uptake; full georeferenced data would be required for an accurate assessment.
Farm-scale	Medium	Local ground-truthing of the location of habitat creation would address the question but the sample size is likely to be too small for a confident assessment.
Finding		
Combined confidence level	Medium	The requirement for fully georeferenced spatial data to enable an accurate national-scale assessment combined with relatively small sample sizes in farm-scale monitoring will provide only an adequate assessment of this indicator.
Monitoring		
Ability to deliver	Medium	The relationship between proximity to core area is not part of the CS targeting. Supporting guidance is available but is less likely to be acted on compared to explicit spatial targeting.

There is high confidence in the benefits of habitat creation close to existing habitats. At the national-scale fully georeferenced data would be required for a complete picture, while farm-scale monitoring would provide the ground-truthing but is unlikely to provide a national view. Current targeting in CS aims to promote habitat creation within ecological networks so are likely to provide some benefit.

Indicator B7: Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species

Table 6-13 Summary of findings - Indicator B7

Element	Confidence level	Justification
Justification of adaptation indicator	High	Recent evidence suggests that for many species habitat creation within 1 km of existing woodland is optimal.
Data		

National-scale	Medium	Existing agri-environment schemes point data provides a good picture of uptake; full georeferenced data would be required for an accurate assessment.
Farm-scale	Medium	Local ground-truthing of the location of habitat creation would address the question but the sample size is likely to be too small for a confident assessment.
Finding		
Combined confidence level	Medium	The requirement for fully georeferenced spatial data to enable an accurate national assessment combined with relatively small sample sizes in farm-scale monitoring will provide an adequate assessment of this indicator.
Monitoring		
Ability to deliver	Medium	The relationship between proximity to core area is not part of the CS targeting. Supporting guidance is available but is less likely to be adhered to compared with explicit spatial targeting.

There is high confidence in the benefits of habitat creation close to existing habitats. At the national-scale fully georeferenced data would be required for a detailed assessment whilst, at the farm-scale, monitoring would provide the necessary ground-truthing. Current targeting in CS aims to promote habitat creation within ecological networks so are likely to have a benefit.

C. Protecting refugia

Indicator C1: Creation options, restoration and maintenance of habitats will be focussed on areas with high habitat potential to provide refugia

Table 6-14 Summary of findings - Indicator C1

Element	Confidence level	Justification
Justification of adaptation indicator	Medium	Evidence for the existence of potential climate change refugia are well described in the literature but how to maximise their potential in the context of agri-environment schemes is less well understood.
Data		
National-scale	Medium	10 km x 10 km maps are available depicting refugia potential scores (0=low refugium potential, 1=high refugium potential) however, other local-scale factors (i.e. microclimates/micro-typography) are likely to play a significant role in their persistence that are not well captured by coarser analyses.
Farm-scale	Medium	Descriptive guidance on what promotes micro-refugia is available but data is not available spatially. Farm-scale monitoring should be able to provide a qualitative assessment of both the presence of refugia and option coverage.
Finding		
Combined confidence level	Medium	10 km x 10 km maps are useful in understanding broader-scale changes in refugium potential but refugia is likely to be location-specific and small microclimatic impacts will be as important at the finer scale. Scale is therefore an issue.
Monitoring		
Ability to deliver	Low	The spatial data on national refugia and guidance on how to interpret it is available, however it is not included in Higher Tier targeting and scoring.

There is increasing evidence for the location of refugial areas at the national-scale which is available spatially. At the farm-scale evidence exists on the importance of topographic heterogeneity and reliable water supply in supporting micro-refugia, however useable guidance on their identification is not available. There is also uncertainty around what the appropriate adaptation responses should be, both ecologically and also through agri-environment schemes.

D. Planning for potential changes in ranges and assemblages of species

Indicator D1: Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions

Table 6-15 Summary of findings - Indicator D1

Element	Confidence level	Justification
Justification of adaptation indicator	Low	This is a developing field and the evidence base is evolving. Systematic conservation planning techniques that identify high priority areas for conservation based on the principle of complementarity (i.e. areas that together would protect the greatest number of species) are well-developed and tested. Recent research applying these techniques to new models of climate suitability for species enables us to make some tentative conclusions about areas that will become a higher conservation priority under projected changes in climatic conditions across England. However, it is hard to make precise predictions or determine the appropriate adaptation responses.
Data		
National-scale	Low	Maps at 10 km x 10 km resolution that depict priority areas (0=low conservation priority, 1=high conservation priority) for current and future distributions of a number of species under a low climate scenario are available.
Farm-scale	n/a	This indicator is not appropriate for farm-scale evaluation.
Finding		
Combined confidence level	Low	National monitoring only.
Monitoring		
Ability to deliver	Low	There is no targeting or prioritisation in relation to this indicator. It will only be delivered if the actions align with other priorities e.g. indicator A1, A2.

Indicator D2: Agri-environment scheme options will be targeted and applied appropriately to reflect species turnover in different locations

Table 6-16 Summary of findings - Indicator D2

Element	Confidence level	Justification
Justification of adaptation indicator	Low	This is a developing field and the evidence base is developing. Systematic conservation planning techniques that identify high priority areas for conservation based on the principle of complementarity (i.e. areas that together would protect the greatest number of species) are well-developed and tested. Recent research applying these techniques to new models of climate suitability for species enables us to make some tentative conclusions about areas that will become a higher conservation priority under projected changes in climatic conditions across England. However, it is hard to make precise predictions.
Data		
National-scale	Low	Maps at the 10 km resolution showing rates of protected species turnover are available. These maps provide a measure of species turnover. They are based on climate envelope modelling of existing UK species and exclude potential new arrivals.
Farm-scale	n/a	This indicator is not appropriate for farm-scale evaluation.
Finding		

Combined confidence level	Low	National monitoring only.
Monitoring		
Ability to deliver	Low	There is no targeting or prioritisation in relation to this indicator. It will only be delivered if the actions align with other priorities e.g. indicator A1, A2.

The evidence base is still in development in support of this indicator. Although the emerging evidence suggests differential importance at the 10 km x 10 km scale, this suggests that prioritisation should be adjusted; this has not been translated into formal guidance. Current targeting and prioritisation of CS is unlikely to deliver the desired success criteria.

E. Restoring ecosystems

Indicator E1: Creation and restoration options will be focussed within areas supporting the outcome 1D objective

Table 6-17 Summary of findings - Indicator E1

Element	Confidence level	Justification
Justification of adaptation indicator	High	The benefits of ecosystem restoration to climate change adaptation and EbA are well grounded.
Data		
National-scale	Medium	Accurate geospatial data exists on the location of 1D target areas. Available agri-environment schemes data uses parcel centroids; full georeferenced data would improve the analysis. GI analysis of options is likely to provide only a partial picture of ecosystem restoration.
Farm-scale	High	Existing data from FEP and BEHTA combined with site visit and discussion with land owner will enable an accurate view of whether ecosystem restoration will be achieved.
Finding		
Combined confidence level	High	The combination of national and farm-scale monitoring will provide a robust assessment of this indicator.
Monitoring		
Ability to deliver	Medium	Spatial data and guidance on the delivery of Bio 2020 1D is available. 1D however is not scored for in the Higher Tier of CS and therefore is likely to be delivered as part of other habitat creation objectives.

The restoration of ecosystems is a key objective of Bio 2020; this has been interpreted through the development of spatial opportunity mapping to produce 1D target areas. These are spatially explicit so monitoring the delivery of this indicator requires spatially explicit data, so the current use of centroid data suffers from the same limitations as early indicators that require precise georeferenced data. In addition, to deliver ecosystem function, adjustment in land use in the surrounding area may also be required. This additional requirement will not be picked up in national monitoring. Farm-scale monitoring will provide a more accurate picture of ecosystem restoration. Although spatial layers and guidance exist, the current targeting and scoring does not prioritise 1D actions so the outcome will be delivered as part of other broader habitat creation targets.

F. Making species populations more resilient

Indicator F1: Creation options around existing semi-natural areas will create larger conservation sites

Table 6-18 Summary of findings - Indicator F1

Element	Confidence level	Justification
Justification of adaptation indicator	High	There is a strong evidence base in the scientific literature for the expansion of existing core areas to promote the ecological resilience of existing patches and the coherence of ecological networks.
Data		
National	Medium	Accurate geospatial data exists on the location of existing patches. Available agri-environment schemes data uses parcel centroids; full georeferenced data would improve the analysis.
Farm-scale	High	Existing data from FEP and BEHTA combined with site visits and discussion with land owners will enable an accurate view to be gathered.
Finding		
Combined confidence level	Medium	The combination of national and farm-scale monitoring will provide partial assessment of this indicator but the lack of fully georeferenced agri-environment schemes data and the likely small sample size of agreements with habitat creation options mean that a comprehensive assessment is unlikely.
Monitoring		
Ability to deliver	Medium	Habitat creation is prioritised and scored under the Higher Tier of CS. Guidance is available on the importance of increasing patch size and proximity but this is not associated with scoring so is less likely to be implemented.

Evidence for the importance of increasing patch size in relation to building the resilience of existing patches and ecological networks is increasing. Spatial information of existing patches is available. Monitoring this indicator at the national-scale as with previous spatially explicit indicators would be improved by the use of fully georeferenced data. Farm-scale evaluation would provide an accurate ground-truthing however the likely small sample size of agreements with habitat creation options will limit its national interpretation.

Indicator F2: Creation options increase the topographic heterogeneity of habitats

Table 6-19 Summary of findings - Indicator F2

Element	Confidence level	Justification
Justification of adaptation indicator	High	The benefit of topographic heterogeneity for promoting the persistence of species under climate change has been demonstrated. Creation options can be used to increase the range of topography covered thereby increasing the range and availability of microclimate.
Data		
National	Medium	Accurate geospatial data exists on topography. Available agri-environment schemes data uses parcel centroids; full georeferenced data would improve the analysis.
Farm-scale	High	Existing data from FEP and BEHTA combined with site visits and discussion with land owners will enable an accurate view to be gathered.
Finding		
Combined confidence level	Medium	The combination of national and farm-scale monitoring will provide partial assessment of this indicator but the lack of fully georeferenced agri-environment schemes data and the likely

		small sample size of agreements with habitat creation options mean that a comprehensive assessment is unlikely.
Monitoring		
Ability to deliver	Low	Habitat creation is prioritised and scored under the Higher Tier of CS. Guidance on the importance of topographic heterogeneity is available as are the spatial data. However, the promotion of heterogeneity is not prioritised or scored in the Higher Tier of CS. It is unlikely that the current level of guidance will influence the location of habitat creation in relation to topography.

Topographic heterogeneity promotes diversity of microclimate which in turn has been shown to have benefits for the persistence of species threatened by climate change. Relatively high resolution data exists on topographic heterogeneity. Fully georeferenced agri-environment schemes data would improve the resolution of the analysis but this is less important than for some other spatially dependent indicators. Farm-scale monitoring would be able to provide high resolution ground-truthing. Although spatial data and guidance is available to support this indicator its delivery is not factored into the prioritisation and targeting of habitat creation targets. It is therefore questionable whether this indicator will be delivered under the current CS setup.

G. Improving water quality and reducing flood risk

Indicator G1: Matrix options for soil protection will be focussed in Water Quality Priority Areas

Table 6-20 Summary of findings - Indicator G1

Element	Confidence level	Justification
Justification of adaptation indicator	Medium	Evidence exists on the benefits of employing specific land management activities on water quality.
Data		
National-scale	Medium	The data is available and has been quality checked. The Indicator needs to factor in the concentration of option uptake within WQPAs relative to the national average for the selected options. The proposed RAG assessment at the farm-scale monitoring is likely to include a degree of subjectivity and hence will require clear guidelines for assessors to ensure consistency.
Farm-scale	High	Existing data from FEP and BEHTA combined with site visits and discussion with land owners will enable an accurate view to be gathered.
Finding		
Combined confidence level	Medium	This will indicate placement of options but will not be able to assess actual impacts on water quality. It does not take into account any potential impacts of climate change on the relative priorities of different locations for water quality (no evidence available).
Monitoring		
Ability to deliver	High	Water quality is an established priority of agri-environment delivery.

Water quality is a key consideration in an assessment of land management and climate change adaptation. Whilst significant data is available, particularly relating to water quality, there is less information available and greater uncertainty, on how climate change affects the geographical pattern of water quality and quantity risks and of how land management interventions can mediate those risks. Nevertheless, this is an important issue for inclusion in a monitoring framework. Due to the recent and current focus of agri-environment programmes on water quality, there is good data available. Whilst more in-depth analysis already exists in relation to agri-environment delivery and water quality, for this single measure it will be important to compare the concentration of option uptake in priority areas against the overall national concentration of uptake of the relevant options.

Indicator G2: There will be a greater concentration of relevant agri-environment options within flood prone areas to reduce risk

Table 6-21 Summary of findings - Indicator G2

Element	Confidence level	Justification
Justification of adaptation indicator	High	Evidence of the benefits of nature-based solutions to flooding through the restoration of habitats is well developed.
Data		
National-scale	Low	Appropriate option selection is likely to be dependent on place-based issues and therefore likely to be highly specific. A national-scale analysis is unlikely to pick up anything more than general patterns.
Farm-scale	Medium	Farm-scale monitoring will be able to determine the location and potential benefit of options. The small sample size of agreements within flood prone areas may make drawing overall conclusions difficult.
Finding		
Combined confidence level	Medium	Monitoring would necessarily rely on the sample based farm-scale monitoring. This will be based on professional judgement of the surveyor on the appropriateness of options selected and their location. Hence, clear guidance would be required to ensure consistency across all surveyors.
Monitoring		
Ability to deliver	Medium	Whilst water quality is a clear priority of scheme delivery, it is currently unclear to what extent delivery is to be focussed on flood risk management in future. This is part is due to the requirement for locally specific intervention.

As flood risk is considered one of the early – and most significant – of climate change impacts (subject to issues of attribution) and given the increasing recognition of the role of land management in managing flood risk, it is important that a monitoring protocol should address the issue. However, given the current state of knowledge and data availability, this can only be monitored at the farm level where it should be possible to use professional judgement to assess the appropriateness of option location and significance of impact.

Indicator G3: Agri-environment schemes will support the objectives of the Woodlands for Water programme

Table 6-22 Summary of findings - Indicator G3

Element	Confidence level	Justification
Justification of adaptation indicator	High	Evidence of the ecosystem service benefits provided by woodlands are well documented and understood.
Data		
National-scale	Low	Due to data licensing restrictions, we were unable to gain access to the EA's Woodlands for Water dataset.
Farm-scale	High	Farm-scale review of option placement in relation to Woodlands for Water opportunity mapping would be possible.
Finding		
Combined confidence level	Medium	This relies on the farm-scale, which is in turn based on a potentially time consuming field assessment and potentially small sample size.
Monitoring		
Ability to deliver	Medium	Woodland for Water opportunity mapping data is available, but not reflected in scoring.

The evidence base supporting the use of woodland planting to support nature based flood alleviation is developing. Unfortunately, the data was not available for this project so a national baseline assessment was not possible. The opportunity mapping is available as guidance for CS applications but is not related to scoring making significant progress towards this indicator unlikely.

H. Storing and sequestering carbon

Indicator H1: Agri-environment schemes contribute to the storage and sequestration of carbon

Table 6-23 Summary of findings - Indicator H1

Element	Confidence level	Justification
Justification of adaptation indicator	High	The evidence of the degree to which land use and land management promotes carbon storage and sequestration is well developed.
Data		
National-scale	Medium	Available agri-environment scheme data delineates areas and the (centroid) location of options (using point data). The underpinning targeting data for options that benefit carbon storage and sequestration have been developed to support agri-environment schemes (although it is recognised that carbon storage and sequestration are unlikely to be a primary driver of option uptake). However, there are many areas of uncertainty (i.e. the efficiencies of the measures adopted) meaning that it will provide a good rather than full assessment.
Farm-scale	Medium	Agreement level monitoring would ground truth the area and location of appropriate options. The same issues relating to the uncertainty of storage and sequestration remain.
Finding		
Combined confidence level	Medium	The combination of national and farm-scale monitoring will provide an adequate assessment of this indicator
Monitoring		
Ability to deliver	Medium	Spatial data and guidance is available to support advisor decision making. The current Higher Tier scoring does not prioritise targeting in relation to this objective.

Agri-environment schemes have an overarching objective to support and deliver mitigation. This indicator aims to determine how effective the schemes are at delivering Ecosystem based Mitigation (EbM). Spatial data on the carbon storage and sequestration potential have been developed to support this aim. The data represents the most up to date assessment but high levels of variance are associated with such national assessments. The ability of options to store or sequester carbon is also highly variable depending on local conditions, habitat quality and potential displacement. The spatial datasets are available to advisors with supporting guidance. Carbon storage and sequestration are not scored under the Higher Tier of Countryside Stewardship.

I. Targeting and applying interventions in a cost-effective and adaptive way

Indicator I1: Adaptation in the natural environment will be consistent with agricultural adaptation

Table 6-24 Summary of findings - Indicator I1

Element	Confidence level	Justification
Justification of adaptation indicator	n/a	This indicator has been developed to monitor the "opportunity cost" in terms of loss of potential agricultural productivity of adaptation interventions. However, this should not determine the targeting of habitat creation priorities and there are gaps in our understanding of adaptation priorities in alternative land use sectors.
Data		
National-scale	Medium	All data is widely available and quality checked. ALC criteria are based on the productivity of a narrow range of crops currently grown in the UK.

Farm-scale	High	The location of habitat creation options can be accurately ground-truthed alongside checking the actual quality of the land.
Finding		
Combined confidence level	High	The combination national and farm-scale monitoring will provide an accurate assessment of this indicator.
Monitoring		
Ability to deliver	n/a	This is not factored in to scheme delivery, although evidence indicates that agreement holders will seek to minimise impacts on agricultural productivity.

This Indicator seeks to recognise that habitat creation to support adaptation in the natural environment can incur an opportunity cost in the form of reduced potential for alternative land uses. The pressures on land use in the UK are well documented, including the need to provide homes, produce food, make space for nature and all in the context of climate change. However, our understanding of the potential for these opportunity costs is limited. This is an area where assessments can, and perhaps should, be developed.

Indicator I2: Options will be implemented in a flexible way to facilitate adaptive management

Table 6-25 Summary of findings - Indicator I2

Element	Confidence level	Justification
Justification of adaptation indicator	High	Ensuring that agri-environment schemes promote flexibility, both in terms of the capacity of agreement holders to respond to increased climate uncertainty and also in the promotion of a range of adaptive responses, should underpin current and future agri-environment scheme design and delivery.
Data		
National-scale	Medium	Data is not available to adequately assess the ability of options (including objective setting, option deployment and prescription setting). This should be delivered at local scales. An audit of scheme structure and operation should be undertaken at the start of new schemes to review the likely impact of flexibility of delivery.
Farm-scale	High	Consultation with the land owner and a review of prescriptions, derogation and amendment history.
Finding		
Combined confidence level	Medium	Assessment of flexibility will be qualitative. A RAG or simple scoring system would be appropriate.
Monitoring		
Ability to deliver	Low	Existing compliance and verification requirements restrict the ability of the scheme to develop flexible approaches.

Flexibility is essential when responding to climate change. Ensuring that agri-environment schemes promote flexibility both in terms of the capacity of agreement holders to respond to increased climate uncertainty, and also in the promotion of a range of adaptive responses, should underpin current and future agri-environment schemes design and delivery. To respond to the greater uncertainty that climate change brings and the increased variation in weather events, greater flexibility will be required with regard to option deployment and prescription setting. Flexibility should also be promoted in adaptation responses that should be tailored to local conditions and pressures.

Indicator I3: Agri-environment options will accommodate change where appropriate

Table 6-26 Summary of findings - Indicator I3

Element	Confidence level	Justification
Justification of adaptation indicator	High	Climate change will lead to changes to both the natural environment and agriculture. Ensuring that agri-environment schemes accommodate change where it is inevitable is

		essential for the adaptation of agriculture and the natural environment.
Data		
National-scale	Medium	Data is not available to adequately assess the ability of options (including objective setting, option deployment and prescription setting) to accommodate change. This should be delivered at local scales. An audit of scheme structure and operation including environmental audits should be undertaken at the start of new schemes to review the ability of schemes to accommodate change.
Farm-scale	High	A review of the previous (FEP or FER, where available) and current (BEHTA) environmental audit in relation to prescription and objective setting. Supported by a review of derogation and amendment history of previous agreements will enable a RAG assessment to be undertaken.
Finding		
Combined confidence level	Medium	Assessment of the ability to accommodate change will be qualitative. A RAG assessment or simple scoring system would be appropriate.
Monitoring		
Ability to deliver	Medium	The relatively short length of the majority of agreements (five years) will enable relatively frequent review. Much will depend on the environmental auditing and review process when setting up new agreements.

Climate change is resulting in changes to both the natural environment and agriculture in the UK. Agri-environment schemes need to accommodate these changes where they are inevitable without compromising the environmental objectives of the scheme. Analysis of the spatial uptake of options will not provide a suitable national-scale monitoring framework. Therefore, a review of scheme structure and operation in relation to accommodating change may be beneficial during the development of new schemes. At the farm-scale an assessment using current and previous environmental audits in relation to objective and prescription setting should enable a simple RAG assessment to be developed. The shortening of the length of agreement from 10 years under HLS to five years under CS should improve the ability of agri-environment schemes to accommodate change.

6.3. Monitoring at the national- and farm-scales

Using the themes from the NAP as a starting point, the project considered the full range of adaptation principles to identify a series of environmental and ‘ways of working’ outcomes that fall within the scope of delivery through an agri-environment scheme. These outcomes have been described and indicators developed (see Section 2.1.1.2) to enable national- and farm-scale monitoring (see Sections 2 and 5, respectively). It is proposed that national-scale monitoring includes a review of scheme structure and operation, combined with a spatial analysis of patterns of uptake based upon the indicators outlined (see Section 2.1.1.2). It is recommended that the national-scale approach be supported and ground-truthed by farm-scale monitoring involving field surveying, consultations with land-owners and reviews of agreement operation, option and prescription choice (see Section 5). The monitoring framework (see Table 5-3) provides a robust mechanism to evaluate the ability and progress of current and new schemes to deliver climate change adaptation, EbA and EbM. The indicators have been selected as being within the ability of agri-environment scheme to deliver. We have then assessed whether the current agri-environment schemes design and operation will be able to deliver positive change to the indicators.

Undertaking the work has highlighted the complexity of translating high-level adaptation principles into questions and indicators that can be monitored at different spatial scales. At the national-scale, the location-specific nature of the threats (and opportunities) that climate change poses, and the range of appropriate adaptation responses, makes identifying measurable and standardised indicators a challenge. This is often further compounded by a lack of data richness (i.e. lack of detail) and sometimes poor granularity of data (i.e. ES point centroid data); although it is acknowledged that data richness will improve with the roll out of Countryside Stewardship. Monitoring at the farm-scale provides the resolution necessary to determine local issues and evaluate the contribution that schemes are making to appropriate delivery. The farm-scale also provides the opportunity to monitor not just where the schemes are operating, but also how the scheme is operating on the ground and if delivery is effective, including at the catchment or landscape scale, thereby enabling an assessment of the ability of schemes to deliver the necessary flexibility and promotion of adaptive management on-farm. However, ensuring sufficient coverage to determine clear patterns at the national-scale will be a challenge. This makes monitoring at a range of spatial scales, a prerequisite for assessing the contribution that agri-environment schemes can make to climate change adaptation.

The national element of monitoring requires both an assessment of the scheme structure and design, and the data on the spatial pattern of uptake. These will need to be undertaken at different times in the evolution of the scheme. The assessment of scheme design should be undertaken early in the scheme development so that findings can be incorporated at the earliest opportunity. It is therefore imperative that climate change input is sought early in the development of the replacement of the RDPE.

Assessment of scheme uptake should be undertaken periodically and/or towards the end of the scheme life. The current assessment was undertaken using the full ES uptake (as of 1st January, 2015). This enabled the spatial uptake patterns to be considered in light of the scheme design, targeting and prioritisation specific to ES. The complexity of undertaking a national assessment that requires information on multiple schemes would be far greater and therefore should be avoided. Not only would they operate under different design criteria but the data is likely to be gathered on different systems and the range of options also differs considerably.

What has been apparent during the development of the project is the wide range of spatial data on both the uptake of agri-environment schemes and also the underpinning environmental data that is required for a national-scale assessment. With regard to the agri-environment scheme data, the availability of data at relatively fine resolution (either field centroid or fully georeferenced data) is fundamental, especially to monitor those metrics that require greater granularity, such as fragmentation (indicators B1, B2, B3, B4, B5, B6 and B7) or making existing sites larger (indicator F1). It is therefore imperative that data captured and managed from CS is of a sufficient richness (i.e. providing detailed data), and quality, to facilitate future scheme monitoring.

The project was also able to make use of many existing and freely available spatial datasets that themselves describe the underlying environmental landscape. However, in some cases, the data either did not exist, or was not publicly available (e.g. some information on riverine shading and flooding). For future monitoring, it is therefore important that existing datasets are made available and additional data on understanding the benefits of agri-environment schemes to reducing flood risk is created; fully georeferenced (and quality checked) agri-environment scheme data should also be made available.

6.3.1. Contribution of agri-environment schemes to climate change adaptation

A. Protecting the most important and vulnerable sites

The results of the national baseline assessment (Section 4) demonstrate that current agri-environment schemes are making some contribution to delivering adaptation and EbA. However, the extent to which they are doing so varies considerably. The greatest contribution is where the climate change outcome overlaps with other key objectives of the scheme, such as delivery of commitments to biodiversity (see in particular indicator A1). This is to be expected as the targeting of semi-natural habitats is a key component of the scheme through meeting Bio2020 objectives. For example, a high proportion of eligible blanket bog (92%), upland heathland (88%), upland hay meadows (86%) and fragmented heath (82%) are under appropriate management (selected maintenance and restoration options). Indeed, ensuring that existing semi-natural habitats are protected has been a priority of agri-environment management since the onset of the schemes. This has been further reinforced by additional targets such as the Public Service Agreement (PSA) target for ensuring that 95% of SSSIs are in favourable or recovering condition. Generally, therefore, there is a high level of coverage. However, there is considerable variation within habitats. For example, habitats such as mudflats (4%) and saline lagoons (12%) are less well covered by appropriate options. This is not surprising (due to the requirement for agri-environment schemes to operate on land within the UAA) but consideration should be given to identifying appropriate levers to promote adaptation on these habitats. In addition, the introduction of Permanent Ineligible Features (PIFs) in CS will further reduce the eligibility of some mosaics (e.g. woodland patches/trees with grassland). Overall, it is likely that agri-environment management will deliver this outcome.

For SSSIs (indicator A3), although a key indicator, the picture is less clear. Despite targeting of agri-environment schemes to protect these areas, the lack of availability of high resolution agri-environment scheme data (e.g. fully geoferenced data as output from GENESIS) means that assessment at the national-scale is unclear. Therefore, this data is fundamental in understanding spatial uptake of agri-environment management at the national-scale whilst farm-scale monitoring is a useful/additional substitute at present.

Targeting the most sensitive habitats to climate change can help to build resilience (see indicators A4 and A5). It is often the case that many of the highly sensitive habitats (e.g. lowland raised bog and coastal saltmarsh) do not have large areas in the UAA (see Table 4-2), and therefore are not easily targeted under ES; or they do not have appropriate options to increase resilience (e.g. saline lagoons and maritime cliffs and slopes). Conversely, coastal and floodplain grazing marsh and upland hay meadows are both highly sensitive and have good option coverage although, particularly at the coast, multiple pressures may mean that putting agri-environment management in place may be increasingly more difficult (i.e. due to access and/or coastal change) with climate change. When looking at habitat creation in more detail (indicator A5) the resolution of the agri-environment data is not sufficient to draw sensible conclusions regarding the ability of agri-environment schemes to compensate for projected losses of different habitats. It is therefore recommended that farm-scale monitoring is used to identify these changes as the target habitats will be recorded at the agreement level.

B. Reducing fragmentation and enhancing ecological networks

Traditionally, conservation effort has focused on building resilience through actions to reduce non-climatic adverse drivers on existing biodiversity, such as inappropriate management and diffuse pollution. Since the Lawton report (Lawton *et al.*, 2010), there has been additional focus on strengthening ecological networks through addressing fragmentation. The current pattern of uptake (see indicators B1, B2 and B5) demonstrates that agri-environment management is making a limited contribution to these objectives. There is little evidence to suggest that highly fragmented areas are the focus of habitat creation. In addition, there is very little difference in the uptake of selected core creation options between areas that are highly fragmented and those that are less highly fragmented. For all fragmentation indicators of priority habitats (B1, B2 and B5), there is little evidence of geographical targeting. There is evidence of slightly more restoration (B2) in highly fragmented areas. For woodland creation (indicator B7) the pattern of uptake is inconclusive and further study is required.

C. Protecting refugia

Although the evidence for the existence of landscape scale climate change refugia is new and agri-environment scheme prioritisation has not been targeted for them, habitat creation appears to favour (i.e. there is a greater concentration in) areas with high refugia potential. There is also greater uptake of maintenance and restoration of habitats within areas of high refugia potential than within areas with low refugia potential.

D. Planning for potential changes in ranges and assemblages of species

Conservation management can only be applied over a relatively small percentage of the land area and therefore needs to be carefully managed on the most important places. Work by the University of York and Natural England (Pearce-Higgins *et al.,* 2015a) is investigating the highest priority areas for the protection of a suite of species. The results here (indicator D1) suggest that there is no relationship, or targeting, of agri-environment schemes to these high priority areas. However, the current evidence base requires further work to support the indicator and the appropriate actions to respond to this objective.

In terms of the targeting of agri-environment schemes to areas of projected high/low species turnover (indicator D2), there is no clear relationship or spatial bias to these areas. The reasons for this are unclear, however a possible cause may be that areas with greater concentrations of semi-natural habitat, and therefore with higher species diversity, are more likely to change; these areas (or rather, the likely changes to these areas) are not reflected in the underlying spatial datasets at present. Further study is therefore required to better understand the relationship between agri-environment management and changes within areas of projected high species turnover.

E. Restoring ecosystems

The commitment to restoring degraded ecosystems via targets delivered as part of the Bio2020 objectives are clear and a range of national-scale targeting layers have been produced and used in this project. However, the limited spatial granularity of the agri-environment scheme data combined with the relatively high resolution targeting layers means that there is limited visible uptake evident within these areas (indicator E1). The current method of assessment at the national-scale is therefore not appropriate. At the farm-scale, the national-scale data may be ground-truthed but current assessment is likely to be insufficient for national reporting of Bio2020 targets.

F. Making species populations more resilient

To improve resilience to climate change ecological networks should be based on a core set of high quality sites of sufficient size. Making existing sites bigger is a recognised method for supporting adaptation goals. Assessment of habitat creation around existing semi-natural areas (indicator F1) suggests that the majority of habitat creation occurs within 1 km of existing priority habitat but not abutting it. This is good for improving connectivity of ecological networks and for building resilience to climate change. For wetland sites, most habitat creation occurs over 1 km from existing wetlands and the reasons for this are unclear. In this regard a clear focus on prioritising habitat creation close to existing wetland sites is needed.

G. Improving water quality and reducing flood risk

Despite strong evidence on the benefits of specific land management activity on improving water quality there is limited evidence of uptake of these options (that support improvements in water quality through protecting soil resources) within high priority areas (indicator G1). Fully georeferenced agri-environment data is required to better assess (and monitor) the contribution of this indicator to climate change adaptation. Clear prioritisation is needed to enable agri-environment schemes to contribute to this indicator.

H. Storing and sequestering carbon

Only peat and blanket peat soils were considered in the national-scale assessment (indicator H1). Uptake of options that support these soils was high on blanket peat soils (~73% covered by options) and very low on peat soils (~91% not covered by options). Although sequestration of carbon is unlikely to be a significant driver of option choice the benefit to climate change mitigation is well established.

I. Targeting and applying interventions in a cost-effective and adaptive way

No national analysis of the ‘ways of working’ indicators was undertaken as they would not be covered by a review of spatial patterns of uptake. However, preliminary conclusions can be drawn from the discussions held and the workshops and the interviews undertaken with key staff. An overarching concern of NE staff is how the recent changes to the inspection and penalty regime is impacting on the ability of agri-environment schemes to support the ways of working required to promote adaptation. The requirement for auditability of options and prescriptions and the potential threat of penalties if indicators of success are not met are likely to increase the conservative nature of agreement holders and advisors when setting up agreements. This will make the accommodation of change, and the requirement for increased flexibility in response to climate change, harder to achieve.

6.3.2. Expected changes in Countryside Stewardship

The baseline assessment is based on the 2015 uptake pattern of ES. Under CS, the coverage of land under agreement will decrease from approximately 70% to 20-30% of the UAA. This reduction largely relates to the removal of the entry level (ELS) element of ES, the policy being that much of the landscape (matrix) activity currently under ELS will be picked up through cross-compliance and greening. In terms of adaptation, this change is not expected to have a proportional impact to the amount of land lost from agri-environment schemes coverage as all (bar a couple of the desired outcomes) are delivered through core options which will remain available under the higher tier of CS.

Up to now, one of the main hurdles to delivering adaptation through agri-environment schemes has been the lack of appropriate tools and mapping to enable effective prioritisation. This project has provided a major step forward in developing measurable adaptation indicators and ways of working outcomes that focus on climate change adaptation, underpinned by spatial data. This will enable prioritisation on par with the other objectives of the scheme through the use of geospatial information-based targeting. Indeed, given the crossover and potential for agri-environment schemes to deliver adaptation, climate change objectives should be fully embedded into scheme design, rather than something that is additional. Other commentators support the recommendation that something should be done (see Hejnowicz *et al.,* 2016), suggesting in a survey of 251 Natural England registered advisors that in no cases did the interviewed advisors think that agreements would meet climate change objectives.

> *In a survey of 251 Natural England registered advisors, in no cases did the advisors think that agreements would meet climate change objectives.*
>
> Source: Hejnowicz *et al*., 2016

Looking forward at the ability of CS to deliver the improvements sought, the current approach of delivering climate change through the delivery of other objectives will only deliver a subset of the desired adaptation outcomes. Those outcomes that align with other priority areas are likely to see gain. For example, ensuring that priority habitat is under appropriate management, and habitat creation and restoration is targeted to reduce fragmentation, aligns with Bio2020 targets 1A and 1B as these outcomes are explicitly targeted in the scheme literature and scoring systems. Maintaining or increasing the high levels of delivery for these objectives is therefore likely. Similarly, actions that support the delivery of the commitment to the Water Framework Directive are also actively prioritised. For other outcomes, especially those that relate to more climate-specific issues, it is less certain that the current situation will improve without modifying the targeting regime.

One of the strengths of the scheme is the flexibility of the scoring and prioritisation systems that enable changes in the focus of the scheme without fundamentally changing the way the scheme operates. This enables the priority of objectives to be altered and new objectives to be incorporated. For example, the ability of agri-environment schemes to support natural flood defence is an area that is receiving greater interest post the flooding events of winter 2015. Accordingly, those objectives that relate to EbA, primarily natural flood relief, may in the future receive greater prioritisation which in turn increases the ability of the scheme to deliver these outcomes.

Where CS is less flexible is in its overall structure which was largely determined prior to the launch of the scheme. How the scheme operates both nationally and on-farm (and in turn how this impacts on the two ways of working outcomes - indicators I1 to I3) is as, if not more important, than the spatial uptake of options. The requirement for all options to be verifiable for compliance purposes, in combination with the current penalty regime is leading to a risk-averse approach to both objective setting and delivery. Such an approach will deter innovative approaches such as adaptive management. It may also lead to focus on activity of lower environmental interest as areas of high biodiversity interest and those where the impact of climate change is leading to environmental change are likely to require complex and, potentially, bespoke management.

Many of the outcomes highlighted in the project can be catered for within CS, however the current prioritisation regime coupled with the compliance regime means that they are unlikely to be fully delivered.

The verifiable requirement for prescriptions makes it harder to set management criteria that are responsive to varying environmental conditions, making it likely that the frequency in the use of derogations as a response to “one-off” events will increase. A less time consuming approach would be to promote flexible prescription setting that accommodates the increased variability in weather. For example, extending time windows for cutting or grazing, or increasing the range of stocking density to account for inter-year variation. An alternative approach would be to link action to environmental conditions, e.g. hedge cutting only taking place before bud burst, rather than a specified date (although it is acknowledged that this may be harder to implement).

This project has reinforced the understanding of the complexity of the issues relating to delivering climate change adaptation (and mitigation). Identifying and delivering appropriate action requires an interpretation of broad issues in light of local conditions. As well as changes to the above, there is a need for advisors to understand the likely impacts of climate change on the environment in their locality and the range of options that promote adaptation, coupled with an understanding of the opportunities (and constraints) that the scheme provides.

The duration of CS agreements offers both a potential opportunity and risk to delivering climate change action. On the positive side, the five-year length of most agreements is relatively short in comparison to the timeframe of climate change impacts. This means that the opportunity exists to review what has worked or failed and reassess the objectives at relatively frequent intervals, a key component of adaptive management. This however is dependent on continuity of ownership/management and advice, an appropriate audit of environmental condition and the ability to alter objectives and prescriptions based on climate projections and monitoring evidence. Historically the FEP provided a relatively robust environmental audit. The BEHTA that underpins option choice and prescription setting is more basic and unlikely to detect/record the necessary direction of travel in environmental condition necessary to make informed decisions. On a more negative note, the short-term nature of agreements mean that there is no guarantee that the actions put in place in terms of habitat maintenance, restoration or creation will continue at the end of the agreement. This issue is not climate change specific but consideration of how to secure, in the long term, the environmental change put in place under agri-environment schemes should be explored.

6.3.3. Wider applications and implications

There are wider applications and implications of the work presented and these may be summarised as follows:

- The work facilitates the reporting on environmental impacts of agri-environment schemes as part of RDPs;
- For the first time in Europe, to our knowledge, we have produced method for assessing the state of adaptation on the ground and of ground-truthing a national-scale baseline assessment (which is essential if EU reporting is to be meaningful);
- The development of the monitoring framework and national-scale baseline assessment can directly influence agri-environment delivery to increase the contribution. The current baseline assessment suggests that we are not reaching full potential and more could be done to prioritise and improve the multiple benefits to the environment provided by agri-environment schemes;
- In undertaking this project, wider links to other Natural England projects are evident, including work on understanding species refugia, fragmentation and Bio2020 targets; and
- Finally, in addition to these direct uses there is potential for wider application of the methodology and monitoring framework developed here to areas outside of the UK i.e. other EU countries that employ agri-environment schemes.

6.4. Recommendations

Based upon our findings, the following additional recommendations were made for the operation of the proposed monitoring methodology:

- The methodology developed for the **on-farm assessment should be integrated with future agri-environment scheme monitoring programmes**. This will require embedding into monitoring programmes that monitor at both the start and end of agreements;
- The national assessment presented here should be **repeated between every 2-5 years** and as indicated (Section 5.3) to coincide with scheme start/end dates. Attention should be made to using the farm-scale assessments to inform the national assessment and to build in lessons learnt and flexibility into the monitoring framework;
- **National monitoring** of spatial uptake patterns should be undertaken at the end of the scheme's life and/or on single schemes;
- **Fully georeferenced data should be collated, quality checked and made available**. Under ES such data is collected using GENESIS. This data needs to be complete and quality controlled to improve the resolution of the national monitoring. This is especially important for those metrics that require detailed spatial resolution. Future schemes including CS should have a data gathering system that provides this data; the spatial data supplied via Genrep enabled the national analysis of most indicators to be undertaken. The current data represents the minimum that is required for reporting. Fully geo-referenced data (as available from Webmap) would significantly improve the resolution of the some of the national analysis that requires precise spatial information; and
- **Underpinning spatial datasets should be made available**. Several datasets held by Defra family organisations were not available for this project.

References

Adaptation Sub-Committee (2013) Managing the land in a changing climate. Progress Report 2013.

Amec (2013) Developing datasets for Biodiversity 2020: Outcome 1D. Project report to Natural England. 128pp.

Angelini, C. and Silliman, B.R. (2012) Patch size-dependent community recovery after massive disturbance. *Ecology*, 93, 101–110.

Boatman, N., Ramwell, C., Parry, H., Jones, N., Bishop, J., Gaskell, P., Short, C., Mills, J. and Dwyer, J. (2008) A review of environmental benefits supplied by agri-environment schemes. Land Use Policy Group. FST20/79/041. 267pp.

Broadmeadow, S., Thomas, H. and Nisbet, T. (2014) Opportunity mapping for woodland creation to reduce diffuse pollution and flood risk in England & Wales. 41pp. Forest Research 2014.

Cabinet Office (2002) Farming & Food: a sustainable future. 152pp. Available here: http://webarchive.nationalarchives.gov.uk/20100807034701/http:/archive.cabinetoffice.gov.uk/farming/pdf/PC%20Report2.pdf [accessed 11th March, 2016]

Commission of the European Communities (2008) Council Regulation amending Regulation (EC) No 1698/2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). Brussels, 20.5.2008 SEC (2008). Available here: http://ec.europa.eu/agriculture/policy-perspectives/impact-assessment/cap-health-check/documents/fullimpact_en.pdf [accessed 11th March, 2016]

Committee on Climate Change, The (2015) Aggregate assessment of climate change impacts on the goods and benefits provided by the UK's natural assets. 183pp.

Committee on Climate Change, The (2016a) Adaptation Indicators. Available here: https://www.theccc.org.uk/charts-data/adaptation-indicators/ [accessed 21st March, 2016]

Committee on Climate Change (2016b) UK Climate Change Risk Assessment 2017 Evidence Report.

Condatis (2016) The Condatis Project. Available here: http://wordpress.condatis.org.uk/ [accessed 16th May, 2016]

Convention on Biological Diversity (2016) National targets. Available here: https://www.cbd.int/nbsap/targets/default.shtml [accessed 23rd March, 2016]

Courtney, P., Mills, J., Gaskell, P. and Chaplin, S. (2013) Investigating the incidental benefits of Environmental Stewardship schemes in England. *Land Use Policy*, 31, 26-37.

Defra (2007a) Conserving biodiversity in a changing change: guidance on building capacity to adapt. 26pp.

Defra (2007b) Rural Development Programme for England 2007–13. Defra, London.

Defra (2008) England Biodiversity Strategy Climate Change Adaptation Principles – Conserving biodiversity in a changing climate. 15pp.

Defra (2011) Biodiversity 2020: A strategy for England's wildlife and ecosystem services. 46pp.

Defra (2012) UK Climate Change Risk Assessment Available here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/ file/69487/pb13698-climate-risk-assessment.pdf [accessed 28th February, 2016]

Defra (2014) Introducing Countryside Stewardship. November 2014. 15pp.

Defra (2015) The new Common Agricultural Policy schemes in England: February 2015 update. Defra.

Donald, P.F. and Evans, A.D. (2006) Habitat connectivity and matrix restoration: the wider implications of agri-environment schemes. *Journal of Applied Ecology*, 43, 209-218.

Doswald, N. and Osti, M. (2011) Ecosystem-based approaches to adaptation and mitigation – good practice examples and lessons learned in Europe. 43pp. Available here: https://www.bfn.de/fileadmin/MDB/documents/service/Skript_306.pdf [accessed 9th March, 2016]

Eigenbrod, F., Gonzalez, P., Dash, J. and Steyl, I. (2014) Vulnerability of ecosystems to climate change moderated by habitat intactness. *Global Change Biology*, 21 (1), 275-286.

English Nature (1996) The Wildlife Enhancement Scheme in the Uplands. No. 199 – English Nature Research Reports. Available here: http://publications.naturalengland.org.uk/publication/212860 [accessed 11th March, 2016]

Environment Agency (2007) Preparing for climate change impacts on freshwater ecosystems (PRINCE). Science report: SC030300/SR. 93pp.

Environment Agency (2011) Woodlands for Water: Woodland measures for meeting Water Framework Directive objectives. Science report: SCHO0711BTYR-E-E. 34pp.

Environment Agency (2012) Keeping Rivers Cool: Getting ready for climate change creating riparian shading. 41pp.

European Commission (2006) Handbook on Common Monitoring and Evaluation Framework. 15pp.

European Commission (2010) Communication from the Commission: Europe 2020. Available here: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF [accessed 2nd September, 2016]

Eycott, A. E., Watts, K. Brandt, G., Buyung-Ali, L.M., Bowler, D.E., Stewart, G. and Pullin, A. (2010) Do landscape matrix features affect species movement. CEE Review 08-006(SR43), 1-20.

Eycott, A. E., Stewart, G. B., Buyung-Ali, L. M., Bowler, D. E., Watts, K. & Pullin, A.S. (2012) A meta-analysis on the impact of different matrix structure on species movement rates. *Landscape Ecology* 27,1263-1278.

Farig, L. (2003) Effects of habitat fragmentation on biodiversity. *Ecology, Evolution and Systematics*, 34, 487-515.

Fischer, J. and Lindenmayer, D.B. (2007) Landscape modification and habitat fragmentation: a synthesis. *Global Ecology and Biogeography*, 16 (3), 265-280.

Forestry Commission (2012) General Guide to EWGS. 24pp.

Forest Research (2016) Habitat networks. Available here: http://www.forestry.gov.uk/fr/habitatnetworks [accessed 24th March, 2016]

Franco, A. M. A., Anderson, B. J., Roy, D. B., Gillings, S., Fox, R., Moilanen, A. and Thomas, C. D. (2009) Surrogacy and persistence in reserve selection: landscape prioritization for multiple taxa in Britain. Journal of Applied Ecology, 46: 82–91.

Gauzere P., Jiguet F. and Devictor, V. (2016) Can protected areas mitigate the impacts of climate change on bird's species and communities? *Diversity and Distributions*, 1–13.

Gillingham, P.K., Alison, J., Roy, D.B., Fox, R. and Thomas, C.D. (2015) High abundance of species in protected areas in parts of their geographic distributions colonized during a recent period of climatic change. *Conservation Letters*, 8 (2), 97-106.

Godfrey, A. (2003) A review of the invertebrate interest of coarse woody debris in England. English Nature Research Report No. 513. Available here: http://publications.naturalengland.org.uk/file/130014 [Accessed 28th March, 2016]

Greenwood, O., Mossman, H.L., Suggitt, A.J., Curtis, R.J. and Maclean, I.M.D. (2016) Using in situ management to conserve biodiversity under climate change. *Journal of Applied Ecology*, 53, 885–894

Haddad, N.M., Brudvig, L.A., Clobert, J., Daviesm, K.F., Gonzalez, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Collins, C.D., Cook, W.M., Damschen, E.I., Ewers, R.M., Foster, B.L., Jenkins, C.N., King, A.J., Laurance, W.F., Levey, D.J., Margules, C.R., Melbourne, B.A., Nicholls, A.O., Orrock, J.L., Song, D-X. and Townshend, J.R. (2015) Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances*, 1 (2), 1-9.

Hansen, L. and Hoffmann, J. (2011) Climate savvy—adapting conservation and resource management to a changing world. Island Press, Washington, DC

Hejnowicz, A.P., Rudd, M.A. and White, P.C.L. (2016) A survey exploring private farm advisor perspectives of agri-environment schemes: The case of England's Environmental Stewardship programme. *Land Use Policy*, 55, 240-256.

Heller, N.E. and Zavaleta, E.S. (2009) Biodiversity management in the face of climate change: a review of 22 years of recommendations. Biological Conservation, 142, 14–32.

Hole, D. G., Huntley, B., Arinaitwe, J., Butchart, S. H. M., Collingham, Y. C., Fishpool, L. D. C., Pain, D. J. and Willis, S. G. (2011) Toward a management framework for networks of protected areas in the face of climate change. *Conservation Biology*, 25, 305–315.

HM Government (2011) The Natural Environment White Paper (NEWP). The Natural Choice: securing the value of nature. Available here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228842/8082.pdf [accessed 23rd, March)

HM Government (2013) The National Adaptation Programme – Making the country resilient to a changing climate. Available here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209866/pb13942-nap-20130701.pdf [accessed 4th March, 2016]

HM Government (2015) Countryside Stewardship: Statements of priorities. Available here: https://www.gov.uk/government/collections/countryside-stewardship-statements-of-priorities [accessed 11th March, 2016]

Hopkins, J.J., Allison, H.M., Walmsley, C.A., Gaywood, M. and Thurgate, G. (2007) Conserving biodiversity in a changing climate: guidance on building capacity to adapt. Department for Environment, Food and Rural Affairs, London

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

IACCF (2010) Biodiversity and Climate Change in the UK. (Eds. Procter, D.A., Baxter, J.M., Crick, H.P.Q., Mortimer, D., Mulholland, F Walmsley, C.A.). JNCC, Peterborough. pp.16. Available here: http://jncc.defra.gov.uk/PDF/Pub10_Bio_&_CC_IACCF_2010_Web.pdf [accessed 4th March, 2016]

IPCC (2013) Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Joint Nature Conservation Committee (JNCC) (2016a) UK BAP priority habitats. Available here: http://jncc.defra.gov.uk/page-5718 [accessed 26th March, 2016]

Joint Nature Conservation Committee (JNCC) (2016b) Annex I habitats and Annex II species occurring in the UK. Available here: http://jncc.defra.gov.uk/page-1523 [accessed 26th March, 2016]

Jones, L., Ludi, E., Carabine, E., and Grist, N. (2014) Promoting adaptation to climate change through Flexible and Forward-looking Decision Making, March 2014, ODI, 203 Blackfriars Road, London.

Knight S, Collins L, Conyers S, Crowe A, Eyre D, Parrott D, Roy S, Somerwill K, Williams J & Boatman N. (2014) Increasing landscape connectivity: evaluating the risks that this will encourage invasive non-native species. pp 211, NECR146, Natural England, Sheffield.

Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.J., Tew, T.E., Varley, J., and Wynne, G.R. (2010) Making Space for Nature: a review of England's wildlife sites and ecological network. Report to Defra. Available here: http://webarchive.nationalarchives.gov.uk/20130402151656/http://archive.defra.gov.uk/environment/biodiversity/documents/201009space-for-nature.pdf [accessed 5th March, 2016]

Lindenmayer, D.B. and Fischer, J. (2007) Tackling the habitat fragmentation panchreston. *Trends in Ecology & Evolution* 22:127–132.

Lindenmayer, D.B. (2009) *Large-scale landscape experiments: lessons from Tumut*. Cambridge University Press.

Living with Environmental Change (LWEC) (2013) Evidence gaps identified through the Terrestrial Biodiversity Climate Change Impacts Report Card process. 4pp. Available here: http://www.nerc.ac.uk/research/partnerships/lwec/products/report-cards/biodiversity/messages/evidence-gaps/ [accessed 9th March, 2016]

Living with Environmental Change (LWEC) (2015) Climate Change Impacts Report Cards. Available here: http://www.nerc.ac.uk/research/partnerships/lwec/products/report-cards/ [accessed 3rd March, 2016]

Living with Environmental Change (LWEC) (2016) Climate Change Impact Card – Agriculture and Forestry. In Press.

Maclean, I.M.D., Hopkins, J.J., Bennie, J., Lawson, C.R. and Wilson, R.J. (2015) Microclimates buffer the responses of plant communities to climate change. Global Ecology and Biogeography, 3-11.

Mainstone, C., Hall, R. and Diack, I. (2016) A narrative for conserving freshwater and wetland habitats in England. Natural England Research Reports, Number 064.

Margules, C.R. and Pressey, R.L. (2000) Systematic conservation planning. *Nature* 405: 243-253.

Mawdsley, J.R., O'Malley, R. and Ojima, D.S. (2009) A review of climate-change adaptation strategies for wildlife management and biodiversity conservation. Conservation Biology, 23, 1080-1089.

Met Office (2009) The climate of the United Kingdom and recent trends. 25pp. Available here: http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87932& [accessed 29th February, 2016]

Ministry of Agriculture, Fisheries and Food (MAFF) (1988) Agricultural Land Classification of England and Wales. Revised guidelines and criteria for grading the quality of agricultural land. 60pp.

Mitchell, R.J., Morecroft, M.D., Acreman, M., Crick, H.Q.P., Frost, M., Harley, M., Maclean, I.M.D., Mountford, O., Piper, J., Pontier, H., Rehfisch, M.M., Ross, L.C., Smithers, R.J., Stott, A., Walmsley, C., Watts, O. and Wilson, E. (2007) England Biodiversity Strategy – Towards adaptation to climate change. Final Report to Defra for contract CR0327.

Morecroft, M., Crick, H.Q.P., Duffield, S.J. and Macgregor, N. (2012) Resilience to climate change: translating principles into practice. *Journal of Applied Ecology*, 49, 547-551.

Morecroft, M.D. and Speakman, L. (eds.) (2013) Terrestrial Biodiversity Climate Change Impacts Summary Report. Living With Environmental Change. (A LWEC Climate change impact report card) Available here: http://www.lwec.org.uk/sites/default/files/attachments_page/Biodiversity%20English%20for%20Web.pdf [accessed 18 February 2015]

Mountford, J.O. and Cooke, A.I. (eds.) Amy, S.R., Baker, A., Carey, P.D., Dean, H.J., Kirby, V.G., Nisbet, A., Peyton, J.M., Pywell, R.F., Redhead, J.W. and Smart, S.M. (2013). Monitoring the outcomes of Higher Level Stewardship: Results of a 3-year agreement monitoring programme. Natural England Commissioned Reports, Number 114

Natural England (2008) Environmental Stewardship Handbook Part A Application Handbook Second Edition – October 2008.

Natural England (2009) Agri-environment schemes in England 2009 A review of results and effectiveness. NE 194. ISBN 978-1-84754-158-1 Natural England, Sheffield, 120pp

Natural England, 2010 Agri-environment schemes in England 2009. A review of results and effectiveness, Natural England, Sheffield.

Natural England (2012a) Evolution of Agri-Environment Schemes in England, NE373. Natural England, Sheffield.

Natural England (2012b) Environmental Stewardship and climate change mitigation. Natural England Technical Information Note TIN107, Natural England, Sheffield.

Natural England (2012c) Agricultural Land Classification: protecting the best and most versatile agricultural land. Natural England Technical Information Note TIN049. 4pp.

Natural England (2012d) Environmental Stewardship and climate change mitigation. Natural England Technical Information Note TIN107. 15pp.

Natural England (2013a) Monitoring the outcomes of Higher Level Stewardship: Results of a 3-year agreement monitoring programme. NECR114. 193pp.

Natural England (2013b) Entry Level Stewardship Handbook. Fourth Edition. 180pp.

Natural England (2013c) Higher Level Stewardship Handbook. Fourth Edition. 120pp.

Natural England (2013d) SSSI Monitoring and Reporting. 14pp. Available here: http://publications.naturalengland.org.uk/file/4564618932387840 [accessed 26th March, 2016]

Natural England and RSPB (2014) Climate Change Adaptation Manual. 222pp. Available here: http://publications.naturalengland.org.uk/publication/5629923804839936 [accessed 1st March, 2016]

Natural England (2014) National Biodiversity Climate Change Vulnerability Model. Natural England Research Report NERR054.

Natural England (2015a) Countryside Stewardship Manual. NE608, ISBN 978-1-78367-203-5. Natural England, Sheffield, pp 93.

Natural England (2015b) Countryside Stewardship statement of priorities: Border Moors and Forests (NCA005). 8pp. Available here: https://www.gov.uk/government/publications/countryside-stewardship-statement-of-priorities-border-moors-and-forests-nca005 [accessed 19th March, 2016]

Natural England (2016) Countryside Stewardship Manual. NE608, ISBN 978-1-78367-203-5. Natural England, Sheffield, pp 93.

Newson, S.E., Oliver, T.H., Gillings, S., Crick, H.Q.P., Morecroft, M.D., Duffield, S.J., Macgregor, N.A. and Pearce-Higgins, J.W. (2014) Can site and landscape-scale environmental attributes buffer bird populations against weather events? *Ecography*, 37 (9), 872-882.

Oliver, T., Girardello, M., Redhead, R., Roy, D., Gillings, S., Newson, S., Pearce-Higgins, J., Siriwardena, G., Harley, M., Hodgson, N., Morecroft, M.D., Duffield, S.J. and Crick, H.Q.P. (2013) Testing the effectiveness of climate change adaptation principles for biodiversity conservation. Natural England Commissioned Reports, Number 112. Natural England, Sheffield.

Oliver, T., Marshall, H., Morecroft, M.D., Brereton, T., Prudhomme, C. and Huntingford, C. (2015) Interacting effects of climate change and habitat fragmentation on drought-sensitive butterflies. *Nature Climate Change*, 5, 941-945.

Opdam, P. and Washer, D. (2004) Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. *Biological Conservation*, 117, 285-297.

Pearce-Higgins, J.W., Ausden, M.A., Beale, C.M., Crick, H.Q.P. and Oliver, T.H. (eds) (2015a) Research on the assessment of risks & opportunities for species in England as a result of climate change. Natural England Commissioned Report 175. Natural England, York

Pearce-Higgins, J.W., Eglington, S.M., Martay, B. and Chamberlain, D.E. (2015b) Drivers of climate change impacts on bird communities. *Journal of Animal Ecology*, 84 (4), 943-954.

Peterken, G.F. and Hughes, F.M.R. (1995) Restoration of floodplain forest in Britain. *Forestry*, 68, 187-202.

Riutta, T., Slade, E.M., Morecroft, M.D., Bebber, D.P. and Malhi, Y. (2014) Living on the edge: quantifying the structure of fragmented forest landscape in England. *Landscape Ecology*, 29, 949-961.

Schmitz, O.J., J.J. Lawler, P. Beier, C. Groves, G. Knight, D.A. Boyce Jr., J. Bulluck, K.M. Johnston, M.L. Klein, K. Muller, D.J. Pierce, W.R. Singleton, J.R. Strittholt, D.M. Theobald, S.C. Trombulak, and A. Trainor. 2015. Conserving biodiversity: Practical guidance about climate change adaptation approaches in support of land-use planning. *Natural Areas Journal* 35:190-203.

Skirvin, D., Plummer, K., Crowe, A., Jones, J.I., Boatman, N. and Siriwardena, G. (2013) 'Synthesising Review' of the use of Environmental Stewardship for restoring, maintaining and enhancing a coherent ecological network in England. Contract report BD5010 to Defra. Department for Environment, Food and Rural Affairs.

Smith, R. J., Eastwood, P. D., Ota, Y. and Rogers, S. I. (2009) Developing best practice for using Marxan to locate Marine Protected Areas in European waters. ICES *Journal of Marine Science*, 66: 188–194.

Stein, B.A., Staudt, A., Cross, M.S., Dubois, N.S., Enquist, C., Griffis, R., Hansen, L.J., Hellmann, J.J., Lawler, J.J., Nelson, E.J. and Pairis, A. (2013) Preparing for and managing change: climate adaptation for biodiversity and ecosystems. *Frontiers in Ecology and the Environment*, 11 (9): 502–10.

Stoate, C., Baldi, A., Beja, P., Boatman, N.D., Herzon, I., van Doorn, A., de Snoo, G.R., Rakosy, L. and Ramwell, C. (2009) Ecological impacts of early 21st Century agricultural change in Europe – A review. *Journal of Environmental Management*, 91 (1), 22-46.

Suggitt, A.J., Wilson, R.J. August, T.A., Beale, C.M. Bennie, J.J., Dordolo, A., Fox, R., Hopkins, J.J., Isaac, N.J.B., Jorieux, P., Macgregor, N.A., Marcetteau, J., Massimino, D., Morecroft, M.D., Pearce-Higgins, J.W., Walker, K. and Maclean, I.M.D. (2014) Climate change refugia for the flora and fauna of England. Natural England Commissioned Report NECR162. 202pp.

Taylor, B.D. and Goldingay, R.L. (2011) Restoring connectivity in landscapes fragmented by major roads: A case study using wooden poles as 'stepping stones' for gliding mammals. *Restoration Ecology*, 20 (6), 671-678.

Thomas, C.D., Gillingham, P.K., Bradbury, R.B., Roy, D.B., Anderson, B.J., Baxter, J.M., Bourn, N.A.D., Crick, H.Q.P., Findon, R.A., Fox, R., Hodgson, J.A., Holt, A.R., Morecroft, M.D., O'Hanlon, N.J., Oliver, T.H., Pearce-Higgins, J.W., Procter, D.A., Thomas, J.A., Walker, K.J., Walmsley, C.A., Wilson, R.J. and Hill, J.K. (2012) Protected areas facilitate species' range expansions. *Proceedings of the National Academy of Sciences of the United States of America*, 109 (35), 14,063-14,068.

Thomas, C.D. and Gillingham, P.K. (2015) The performance of protected areas for biodiversity under climate change. *Biological Journal of the Linnean Society*, 115, 718–730.

Thuiller, W., Lavorel, S., Araujo, M.B., Sykes, M.T. and Prentice, I.C. (2005) Climate change threats to plant diversity in Europe. *Proceedings of the National Academy of Sciences*, 102 (23), 8245-8250.

UKCIP (2006) Identifying adaptation options (AdOpt) guidance. 35pp. Available here: http://www.ukcip.org.uk/wp-content/PDFs/ID_Adapt_options.pdf [accessed 2nd October, 2016]

Watts, K. (2006) British forest landscapes: the legacy of woodland fragmentation. *Quarterly Journal of Forestry*, 100 (4), 273-279.

Woodcock, B., Ball, S., Amy, S., Edwards, M., Redhead, J., Mountford, O., Gregory, S., Duffield, S., Macgregor, N. and Pywell, R. (2015) Final report for the GREEN project (ECM6418): Grassland Restoration for Ecological Networks. Defra, London.

Appendix A. List of datasets

Table A-1 List of datasets, including metadata, what they show and their proposed use

Layer	Theme	Format	Year	Resolution	What does it show?	How was the dataset used?	No.
Environmental_Stewardship_Scheme_Live_Option_Points_External	Agriculture	Point	2015/ 01/01	Parcel level	Environmental Stewardship Live Option Points. Over 1.3 million options are depicted as points. ELS options are depicted as points representing field centroids whilst centroids from the holding are used to denote rotational ELS and HLS options (as these options may be applied within any land parcel within a holding on a rotational basis).	A fundamental dataset used in the analyses to provide locations of the various Environmental Stewardship options.	1
Environmental_Stewardship_Scheme_Live_Agreements_External	Agriculture	Polygon	2015/ 01/01	Agreement level	Environmental Stewardship options depicted at the agreement level (i.e. polygons).	Used as a background dataset to sense check the options (point) data.	-
External_ESA_Classic_Options	Agriculture	Point	2014	Agreement level	ESA options in agreement between 2004-2014	Used for background reference.	-
agri_land_class	Agriculture	Polygon	1988	1:10k – 50k	Agricultural Land Classification Grade for post-1988 ALC surveys. Includes grades 1, 2, 3a, 3b, 4 and 5. For more information see http://publications.naturalengland. org.uk/file/97005. Not updated.	For identifying areas of good (grades 1 to 3) and poor (grades 4 and 5) quality agricultural land.	12
NCA	Landscape	Polygon	2014	Sub-regional	NCAs divide England into 159 distinct natural areas. Each is defined by a unique combination of landscape, biodiversity, geodiversity, history, and cultural and economic activity. Their boundaries follow natural lines in the landscape rather than administrative boundaries.	Used as a framework within which many of the adaptation indicators are reported. Frequently used as a reporting unit.	15
LCM2007	Habitats and soils	Polygon	2007	Land parcels	Remote sensing derived Land Cover map of the UK (2007). See http://www.ceh.ac.uk/services/land-cover-map-2007.	Used for background reference.	-
bap_chalk_rivers_50k	Habitats and soils	Line	2010	Waterbodies	Chalk rivers are recognised as a priority habitat for protection under the UK Biodiversity Action Plan.	Used for background reference.	-
PHI_Central	Habitats and soils	Polygon	2014	Land parcels	UK BAP Priority Habitats for England region (central)	The UK Biodiversity Action Plan (BAP) priority habitats cover a range of semi-natural habitat types. They have been identified as being the most threatened and require conservation action under the UK BAP. Used in most of the analyses.	3
PHI_North	Habitats and soils	Polygon	2014	Land parcels	UK BAP Priority Habitats for England region (North)	As above	3
PHI_South	Habitats and soils	Polygon	2014	Land parcels	UK BAP Priority Habitats for England region (south)	As above	3
External_CSS_Classic_Options	Habitats and soils	Point	2014/ 01/03	Parcel level	Countryside Stewardship Scheme options data	Used for background reference	-
EXTERNAL_CSS_HOLDINGS_LIVE	Habitats and soils	Polygon	2014/ 01/03	Agreement level	Countryside Stewardship Scheme holding data	Used for background reference	-
FCPRODUCT_FC_NAT_INV_WOODLAND_TREES1	Habitats and soils	Polygon	2002	See 'What does it show'	Interpreted Forest Type Woodland Polygon >2ha Data updated by Woodland Surveys for the National Inventory of Woodland and Trees to include Forestry	Used for background reference.	-

Layer	Theme	Format	Year	Resolution	What does it show?	How was the dataset used?	No.
					Commission (FC) new planting and New Woodland Grant Schemes, as at 31st March 2002. Woodland consists of areas of tree cover with a crown density of, or likely to achieve, at least 20%, a minimum width of 50 metres and a minimum area of 2ha. Woodland also includes areas that may temporarily without tree cover following forest clearing. Dataset Information operations such as felling. Within woodlands, internal polygons may be identified with a minimum area of 1ha.		
NATIONAL_FOREST_INVENTORY_GB_2013	Habitats and soils	Polygon	2013	See 'What does it show'	2014 Forestry Commission National Forest Inventory spatial data and associated metadata for England. This dataset includes Interpreted Forest Types (IFTs) for all woodland over 0.5ha and Interpreted Open Area (IOA) information for areas over 0.5ha that are completely surrounded by woodland.	Used for background reference. Provides landscape context.	-
MANAGED_WOODLAND_30June14	Habitats and soils	Polygon	2014/ 30/06	Parcels	Areas of managed (public/private) and unmanaged woodland in England.	Used for background reference. Provides landscape context.	-
CS_CREATION_BIO	Habitats and soils	Polygon	2014/ 12	Parcels	Countryside Stewardship woodland creation scoring, includes Top, Medium and Low spatial priorities. Rules: If 50% (or 3 ha) or more of the case area is priority woodland habitat and at least one block is touching or within a priority area then the application receives the score. If spanning more than one priority area, the score of the relevant highest priority area is awarded.	Used for background reference.	-
PWH_networks_400m	Habitats and soils	Polygon	2013	Corridors	Woodland habitat networks. These are areas of priority woodland that have been buffered by 400m.	Used to identify woodland habitat networks and in understanding fragmentation of woodlands.	13
PWH_networks_600m	Habitats and soils	Polygon	2013	Corridors	Woodland habitat networks. These are areas of priority woodland that have been buffered by 600m.	As above.	13
FCPRODUCT_E_EWGS_GRANTS	Habitats and soils	Polygon	2014/ 31/03	Parcels	The EWGS offers six grants for the creation and stewardship of woodlands and is operated by the Forestry Commission. The component grant types of EWGS (including maintenance, restoration and creation of woodlands) have their own objectives. Some grants are focused regionally to meet the priorities of Regional Forestry Framework action plans, and the objectives are specified more closely to suit.	Used in conjunction with Environmental Stewardship options to identify areas of woodland receiving funding through the EWGS.	2
natmap_vector	Habitats and soils	Polygon	2010	1:250k	1:250,000 scale map of England and Wales, showing the locations of the 297 distinct soil associations wherever they occur within the countries. Within each of the soil associations are multiple soil series.	Used to help understand the soil types over which Environmental Stewardship options are applied.	9
All_Simpson.asc (and others)	Biodiversity	Raster	2014/ 02/12	10km x 10km grids	Maps at the 10km resolution showing rates of species turnover, based on comparing maps of modelled current and future suitable climate created for over 3000 species in the project by Pearce-Higgins *et al.*, (2015a). The calculations of species turnover, by taxa, use three commonly used, but different, measures	Used for identifying areas of high and low species turnover.	16

Layer	Theme	Format	Year	Resolution	What does it show?	How was the dataset used?	No.
					(Whittaker, Sorensen and Simpson). The maps give a simple overall estimate of change in each square; they do not show relative proportions of species arriving, leaving or staying, nor are potential new arrivals to England taken into consideration. The impacts of invasive species are not considered.		
all.asc (and others)	Biodiversity	Raster	2014	10km x 10km grids	Maps at the 10km resolution that depict the priority of areas (0=low conservation priority, 1=high conservation priority) for conserving biodiversity under current and future climatic conditions. They are based on analysis using the Zonation systematic conservation planning software to analyse modelled current and future suitable climate space for over 3000 species.	Used for identifying areas of high and low species turnover due to microclimate only.	11
Nitrate_Vulnerable_Zones_polygon	Other	Polygon	2013	Regions	Areas of England and Wales that are designated as Nitrate Vulnerable Zones (NVZ). NVZs are a form of conservation designation afforded by the Environment Agency for areas of land that drain nitrate into polluted waters, or waters which could become polluted by nitrates.	Used for background reference.	10
Flood Zone 2/3 (and defences, areas benefitting from Flood Defences)	Other	Polygon/ Line	2015	Local	The Flood Map shows the areas across England and Wales that could be affected by flooding from rivers or the sea. It also shows flood defences and for major defences we show the areas that benefit from them. It does not show the effects of climate change. It does not show where flooding from other sources such as groundwater or runoff from rainfall may or may not occur. Updated on quarterly basis.	Used for background reference.	8
ufmfsw_extent_1in100_BV	Other	Polygon	2010	Local	A map of flood risk from surface water for England and Wales produced using updated national-scale modelling, enhanced with compatible locally produced mapping where available. Shows areas at risk of flooding from surface water, for three chances of flooding. It also includes: data on the models used to develop the maps; and information that describes the suitable uses of the data. This Flood Map for Surface Water supersedes earlier EA national-scale maps made available to local resilience forum and local planning authority partners. These were Areas Susceptible to Surface Water Flooding (2008/9) and Flood Map for Surface Water (2010).	Used for background reference.	8
Keeping Rivers Cool	Other	Raster	2012	Waterbodies	A series of maps that delineate riparian shading from trees and vegetation. Areas of riparian shade provide refugial habitat for salmon and brown trout populations that are expected to be at risk from the effects of climate change. Project developed by the Environment Agency.	Used to identify areas that provide riparian shading from trees and vegetation.	18

Layer	Theme	Format	Year	Resolution	What does it show?	How was the dataset used?	No.
CS_Water_Quality_Priority_Areas_15122014	Agriculture	Polygon	2014/ 15/12	Waterbodies	A series of zones that represent delineate priority areas for improving water quality. Scored based on seven different water quality issues, including groundwaters and rivers at risk from nitrate pollution, groundwaters and rivers at risk of pesticide pollution, faecal indicators, sediment risks and phosphate risks.	Used to identify areas that may benefit from improvements in water quality.	17
Biodiversity beneficial options data	Biodiversity	Point	Unknown	Agreement level	The data shows all options that have been active over the past 5 years for Countryside Stewardship, Environmentally Sensitive Area and Environmental Stewardship Schemes. In the case of Environmental Stewardship, option data has been provided for Higher Level and Entry Level Agreements, as some options are available in both scheme strands	Used for background reference.	-
NBCCVM_Most_Vuln_06_12_2013	Biodiversity	Polygon	2013	200 x 200m grids	A number of metrics are used to determine overall vulnerability to climate change in this assessment. Outputs include four metrics - sensitivity to climate change, habitat fragmentation, topographic heterogeneity and management and condition – these are used to determine overall vulnerability for all priority habitats at a 200m x 200m grid resolution. Where two or more habitats are found in a grid square the scores for the most vulnerable habitat overall is presented. See http://publications.naturalengland.org.uk/publication/5069081749225472?category=10003 for more detail.	Pivotal in understanding areas of greatest vulnerability to climate change, including habitat fragmentation and sensitivity.	5
NBCCVM Single Habs NO VAL 11_12_13	Biodiversity	Polygon	2013	200 x 200m grids	This dataset is as above, but this output has been derived using the four metrics, notably: sensitivity to climate change, habitat fragmentation, topographic heterogeneity and management and condition, to assess the vulnerability of priority habitats individually. It depicts overall vulnerability for each priority habitat at a 200m x 200m grid resolution. See http://publications.naturalengland.org.uk/publication/5069081749225472?category=10003 for more detail.	Pivotal in understanding areas of greatest vulnerability to climate change, including habitat fragmentation and sensitivity.	-

Layer	Theme	Format	Year	Resolution	What does it show?	How was the dataset used?	No.
NELMS NBCCVA Habitat Fragmentation Areas	Biodiversity	Polygon	2013	Habitats	These layers depict areas where individual habitats are highly fragmented. These fragmented habitat areas may provide a potential ‘area of search’ for habitat creation opportunities that enhance the habitat network. Two categories of ‘fragmentation area’ (at 1km proximity) are provided for 25 priority habitat types with the ‘top 20%’ areas representing fragmentation areas that have been identified where fragmented habitat patches occur in clusters that are in close proximity to each other and therefore those providing the greatest potential to enhance fragmented habitat networks. Another set of buffers depicts the remaining 80% of fragmented habitat patches that may be more isolated from each other but that may also provide opportunities for reducing fragmentation and increasing habitat patch size. These habitat fragmentation areas were created to assist the targeting of habitat creation under the Biodiversity 2020 target 1B through Countryside Stewardship habitat creation options. The National Biodiversity Climate Change Vulnerability Assessment (NBCCVA) (Taylor et al 2014), described above, which uses a series of metrics to assess the vulnerability of priority habitats to climate change as the base data for this layer. The habitat fragmentation metric from the NBCCVA has been used to identify where areas of the relevant priority habitats are most fragmented, but that exist within a permeable landscape that might allow for habitat expansion, and for appropriate habitats, over a varied topography (this is important for climate change adaptation as it provides variety in microclimate). The fragmented patches of habitat are then assessed for their proximity to each other, the aim being to identify clusters of fragmented habitat patches that could be ‘joined up’ with targeted habitat creation and thereby reducing fragmentation and enhancing the ecological network for that habitat. These fragmented habitat clusters are identified by creating a ‘buffer’ around each fragmented habitat patch and assessing where they overlap, the top 20% largest areas of overlap when the buffers are combined for each habitat are identified as the top potential to reduce fragmentation.	The NBCCVA has resilience building principles as its underpinning rationale; habitat fragmentation, permeability and topographic heterogeneity are key elements of resilience building and adaptation action. The NBCCVA helps apply this when targeting areas for creating or restoring habitat. Used in CS targeting engine, reference dataset in this study.	-

Layer	Theme	Format	Year	Resolution	What does it show?	How was the dataset used?	No.
					These fragmentation areas then provide an 'area of search' for habitat creation opportunities. This data shows Countryside Stewardship habitat targeting areas from NBCCVA. Displayed within relevant Priority Habitats: Lowland Calcareous Grassland (LCG); Lowland Dry Acid Grassland (LDA); Lowland Heathland (LHT); Native Woodland (DW); Lowland Fens (LF); Lowland Raised Bog (LRB); Coastal grazing marsh (CGM); Floodplain grazing marsh (FGM); Purple Moorgrass & Rush Pasture (PMG); Reedbeds (RB); Upland Flushes Fens & Swamps (UFF); Upland Hay Meadows (UHM); Upland Calcareous Grassland (UCG); Upland Heathland (UTH); Blanket Bog (BLB); Maritime Cliffs & Slope (MCS); Woodpasture & Parkland (WPP); Orchards (TOR) and Lowland Meadows (LM/LMW/LMD)		
WFD_Classification_Status_Cycle 2	Other	Excel	2014	Waterbodies	Cycle 2 classification status for surface waterbodies in England	Used for background reference.	-
Anonymised CLAD (Rural Land Register) Parcels	Agriculture	Polygon	2015	Land parcels	Anonymised CLAD Rural Land Register boundaries.	Used to identify land parcels eligible to receive funding through agri-environment schemes. Used in combination with UAA to provide an up to date dataset.	22
HLS non-rotational parcels	Agriculture	Polygon	2015	Options	Fully georeferenced HLS non-rotational options depicting the precise location of these options.	Data not of sufficient quality. Unable to use. Used options points instead.	-
Woodlands for Water	Other	Raster	2015	Waterbodies	Woodland areas providing water quality benefits in the context of the Water Framework Directive (WFD). The project was undertaken by Forest Research and employed spatial mapping to target areas that may contribute most to maximising water and other benefits.	Licensing problems meant that this dataset was not able to be used.	19

Appendix B. UK national biodiversity targets

As a result of new drivers and requirements, the UK Post-2010 Biodiversity Framework (see http://jncc.defra.gov.uk/page-6189), published in July 2012, has succeeded the UK BAP. In particular, due to devolution and the creation of country-level biodiversity strategies, much of the work previously carried out under the UK BAP is now focussed at a country level. Additionally, international priorities have changed: the framework particularly sets out the priorities for UK-level work to support the Convention on Biological Diversity's (CBD's) Strategic Plan for Biodiversity 2011-2020 and its five strategic goals and 20 'Aichi Targets', agreed at the CBD meeting in Nagoya, Japan, in October 2010; and the EU Biodiversity Strategy (EUBS), launched in May 2011. Table B-1 below sets out the UK's targets.

Table B-1 UK national biodiversity targets

Target	Description
Outcome 1	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: (1A-1D below)
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 2	By 2020, we will have put in place measures so that biodiversity is maintained, further degradation has been halted and where possible, restoration is underway, helping deliver good environmental status and our vision of clean, healthy, safe productive and biologically diverse oceans and seas. This will be underpinned by the following: (2A-2C)
Outcome 2A	By the end of 2016, in excess of 25% of English waters will be contained in a well-managed Marine Protected Area network that helps deliver ecological coherence by conserving representative marine habitats
Outcome 2B	By 2020 we will be managing and harvesting fish sustainably
Outcome 2C	By 2022, we will have marine plans in place covering the whole of England's marine area, ensuring the sustainable development of our seas, integrating economic growth, social need and ecosystem management
Outcome 3	By 2020, we will see an overall improvement in the status of our wildlife and will have prevented further human induced extinctions of known threatened species.
Outcome 4	By 2020, significantly more people will be engaged in biodiversity issues, aware of its value and taking positive action.
Priority action 1.1	Establish more coherent and resilient ecological networks on land that safeguard ecosystem services for the benefit of wildlife and people.
Priority action 1.2	Establish and effectively manage an ecologically coherent network of marine protected areas which covers in excess of 25% of English waters by the end of 2016, and which contributes to the UK's achievement of Good Environmental Status under the Marine Strategy Framework Directive
Priority action 1.3	Take targeted action for the recovery of priority species, whose conservation is not delivered through wider habitat-based and ecosystem measures.
Priority action 1.4	Ensure that 'agricultural' genetic diversity is conserved and enhanced wherever appropriate.
Priority action 2.1	Work with the biodiversity partnership to engage significantly more people in biodiversity issues, increase awareness of the value of biodiversity and increase the number of people taking positive action.

Target	Description
Priority action 2.2	Promote taking better account of the values of biodiversity in public and private sector decision-making, including by providing tools to help consider a wider range of ecosystem services.
Priority action 2.3	Develop new and innovative financing mechanisms to direct more funding towards the achievement of biodiversity outcomes.
Priority action 3.1	Improve the delivery of adaptation indicators from agricultural land management practices, whilst increasing food production.
Priority action 3.2	Reform the Common Agricultural Policy to achieve greater environmental benefits.
Priority action 3.3	Bring a greater proportion of our existing woodlands into sustainable management and expand the area of woodland in England.
Priority action 3.4	Through reforms of the planning system, take a strategic approach to planning for nature within and across local areas. This approach will guide development to the best locations, encourage greener design and enable development to enhance natural networks. We will retain the protection and improvement of the natural environment as core objectives of the planning system.
Priority action 3.5	Establish a new, voluntary approach to biodiversity offsets and test our approach in pilot areas.
Priority action 3.6	Align measures to protect the water environment with action for biodiversity, including through the river basin planning approach under the EU Water Framework Directive.
Priority action 3.7	Continue to promote approaches to flood and erosion management which conserve the natural environment and improve biodiversity.
Priority action 3.8	Reform the water abstraction regime. The new regime will provide clearer signals to abstractors to make the necessary investments to meet water needs and protect ecosystem functioning. We will also take steps to tackle the legacy of unsustainable abstraction more efficiently.
Priority action 3.9	Develop 10 Marine Plans which integrate economic, social and environmental considerations, and which will guide decision-makers when making any decision that affects, or might affect, a marine area. This action in England is part of the UK vision for 'clean, healthy, safe, productive and biologically diverse oceans and seas'.
Priority action 3.10	Implement actions and reforms to ensure fisheries management directly supports the achievement of wider environmental objectives, including the achievement of Good Environmental Status under the Marine Strategy Framework Directive.
Priority action 3.11	Reduce air pollution impacts on biodiversity through approaches at national, UK, EU and international levels targeted at the sectors which are the source of the relevant pollutants (nitrogen oxides, ozone, sulphur dioxide, ammonia).
Priority action 3.12	Continue to implement the Invasive Non-Native Species Framework Strategy for Great Britain.
Priority action 4.1	Work collaboratively across Defra and the relevant agencies to direct research investment within Government to areas of highest priority to deliver the outcomes and priorities set out in this strategy, and in partnership with the Research Councils and other organizations in the UK and Europe to build the evidence base.
Priority action 4.2	Put robust, reliable and more co-ordinated arrangements in place, to monitor changes in the state of biodiversity and also the flow of benefits and services it provides us, to ensure that we can assess the outcomes of this strategy.
Priority action 4.3	Improve public access to biodiversity data and other environmental information – putting power into the hands of people to act and hold others to account. Also communicate progress towards the outcomes and priorities of this strategy and make available information to support decision-making at a range of scales to help others contribute to the outcomes.

Appendix C. Sensitivity of different priority habitats to climate change

The table below lists habitat sensitivity as described by three different sources: (i) Natural England and RSPB (2014) Adaptation Manual; (ii) Sensitivity as used in the NBCCVA (see Natural England, 2014); and (iii) an alternative sensitivity defined by the project Steering Group and informed by the two other sources. The Adaptation Manual classification are adapted from Mitchell *et al.,* (2007).

Table C-1 Habitat sensitivity to climate change by source

Priority habitat	Broad grouping	Sensitivity to climate change by source		
		Adaptation Manual	NBCCVA	This project (1=High, 5=Low)
Coastal saltmarsh	Coastal	H	H	1
Montane	Upland	H	H	1
Saline lagoons	Coastal	H	H	1
Standing water	n/a	H	H	2
Lowland fen	Wetland	H	M	1
Rivers and streams	n/a	H	M	2
Upland hay meadows	Grassland	M	H	2
Coastal grazing marsh	Grassland	M	H	3
Lowland raised bog	Wetland	M	H	n/a
Floodplain grazing marsh	Grassland	M	M	2
Purple moor grass and rush pasture	Grassland	M	M	2
Coastal vegetated shingle	Coastal	M	M	1
Lowland meadows (wet)	Grassland	M	M	2
Reedbeds	Wetland	M	M	2
Blanket bog	Upland	M	M	2
Coastal sand dunes	Coastal	M	M	1
Upland fens and flushes	Upland	M	M	1
Lowland heathland	Heathland	M	M	3
Upland heathland	Upland	M	M	3
Intertidal mudflats	Coastal	M	M	2
Lowland beech and yew woodlands	Woodland	M	H	2
Wet woodland	Woodland	M	M	2
Upland mixed ash woods	Woodland	M	L	4
Upland oak wood	Woodland	M	L	4
Maritime cliff and slope	n/a	M	H	1
Limestone pavements	Upland	L	L	4
Lowland meadows (dry)	Grassland	L	L	4
Deciduous woodland	Woodland	L	L	4
Lowland calcareous grassland	Grassland	L	L	5
Lowland dry acid grassland	Grassland	L	L	5
Upland calcareous grassland	Upland / Grassland	L	L	4
Arable field margins	n/a	L	n/a	5
Ancient/species rich hedgerows	n/a	L	n/a	5
Lowland wood pasture and parkland	Woodland	L	L	4
Upland acid grasslands	Woodland	n/a	L	4
Fragmented heathland	Heathland	n/a	n/a	3
Grass moorland	Upland	n/a	n/a	3
Good quality semi-improved grassland	Grassland	n/a	n/a	5
Calaminarian grassland	Upland / Woodland / Heathland / Grassland	n/a	n/a	4

Appendix D. Options relevant to each adaptation indicator

This section lists each of the adaptation indicators used in the baseline assessment and the agri-environment options that were selected as being relevant for each using the Excel tool (see Section 3.1.1.2).

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
Building ecological resilience	The most important sites for biodiversity will be protected	A1: Maintenance and restoration options will be coincident with priority habitats	HC12	Maintenance of wood pasture and parkland
			HC13	Restoration of wood pasture and parkland
			HC15	Maintenance of successional areas and scrub
			HC16	Restoration of successional areas and scrub
			HC18	Maintenance of high value traditional orchards
			HC19	Maintenance of traditional orchards in production
			HC20	Restoration of traditional orchards
			HC7	Maintenance of woodland
			HC8	Restoration of woodland
			HK10	Maintenance of wet grassland for wintering waders and wildfowl
			HK11	Restoration of wet grassland for breeding waders.
			HK12	Restoration of wet grassland for wintering waders and wildfowl
			HK6	Maintenance of species-rich, semi-natural grassland
			HK7	Restoration of species-rich, semi-natural grassland
			HK9	Maintenance of wet grassland for breeding waders
			HL10	Restoration of moorland
			HL9	Maintenance of moorland
			HO1	Maintenance of lowland heathland
			HO2	Restoration of lowland heath
			HO3	Restoration of forestry areas to lowland heathland
			HP1	Maintenance of sand dunes
			HP2	Restoration of sand dune systems
			HP5	Maintenance of coastal saltmarsh
			HP6	Restoration of coastal saltmarsh
			HQ1	Maintenance of ponds of high wildlife value < 100 sq m
			HQ10	Restoration of lowland raised bog
			HQ2	Maintenance of ponds of high wildlife value > 100 sq m
			HQ3	Maintenance of reedbeds
			HQ4	Restoration of reedbeds
			HQ6	Maintenance of fen
			HQ7	Restoration of fen
			HQ9	Maintenance of lowland raised bog
			WMG	Woodland Management Grant
			WRG	Woodland Regeneration Grant
Building ecological resilience	Agri-environment schemes will focus on the best sites	A3: Agri-environment schemes will support SSSIs	HC12	Maintenance of wood pasture and parkland
			HC13	Restoration of wood pasture and parkland
			HC15	Maintenance of successional areas and scrub
			HC16	Restoration of successional areas and scrub
			HC18	Maintenance of high value traditional orchards
			HC19	Maintenance of traditional orchards in production
			HC20	Restoration of traditional orchards
			HC7	Maintenance of woodland
			HC8	Restoration of woodland
			HK10	Maintenance of wet grassland for wintering waders and wildfowl
			HK11	Restoration of wet grassland for breeding waders.
			HK12	Restoration of wet grassland for wintering waders and wildfowl
			HK6	Maintenance of species-rich, semi-natural grassland
			HK7	Restoration of species-rich, semi-natural grassland
			HK9	Maintenance of wet grassland for breeding waders
			HL10	Restoration of moorland
			HL9	Maintenance of moorland
			HO1	Maintenance of lowland heathland
			HO2	Restoration of lowland heath

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HO3	Restoration of forestry areas to lowland heathland
			HP1	Maintenance of sand dunes
			HP2	Restoration of sand dune systems
			HP5	Maintenance of coastal saltmarsh
			HP6	Restoration of coastal saltmarsh
			HQ1	Maintenance of ponds of high wildlife value < 100 sq m
			HQ10	Restoration of lowland raised bog
			HQ2	Maintenance of ponds of high wildlife value > 100 sq m
			HQ3	Maintenance of reedbeds
			HQ4	Restoration of reedbeds
			HQ6	Maintenance of fen
			HQ7	Restoration of fen
			HQ9	Maintenance of lowland raised bog
			WMG	Woodland Management Grant
			WRG	Woodland Regeneration Grant
Building ecological resilience	Action should focus on areas particularly vulnerable to climate change	A4: Restoration and maintenance options will support highly sensitive habitats	HC12	Maintenance of wood pasture and parkland
			HC13	Restoration of wood pasture and parkland
			HC15	Maintenance of successional areas and scrub
			HC16	Restoration of successional areas and scrub
			HC18	Maintenance of high value traditional orchards
			HC19	Maintenance of traditional orchards in production
			HC20	Restoration of traditional orchards
			HC7	Maintenance of woodland
			HC8	Restoration of woodland
			HK10	Maintenance of wet grassland for wintering waders and wildfowl
			HK11	Restoration of wet grassland for breeding waders.
			HK12	Restoration of wet grassland for wintering waders and wildfowl
			HK6	Maintenance of species-rich, semi-natural grassland
			HK7	Restoration of species-rich, semi-natural grassland
			HK9	Maintenance of wet grassland for breeding waders
			HL10	Restoration of moorland
			HL9	Maintenance of moorland
			HO1	Maintenance of lowland heathland
			HO2	Restoration of lowland heath
			HO3	Restoration of forestry areas to lowland heathland
			HP1	Maintenance of sand dunes
			HP2	Restoration of sand dune systems
			HP5	Maintenance of coastal saltmarsh
			HP6	Restoration of coastal saltmarsh
			HQ1	Maintenance of ponds of high wildlife value < 100 sq m
			HQ10	Restoration of lowland raised bog
			HQ2	Maintenance of ponds of high wildlife value > 100 sq m
			HQ3	Maintenance of reedbeds
			HQ4	Restoration of reedbeds
			HQ6	Maintenance of fen
			HQ7	Restoration of fen
			HQ9	Maintenance of lowland raised bog
			WMG	Woodland Management Grant
			WRG	Woodland Regeneration Grant
Building ecological resilience	Action should accommodate change, through the compensation of habitats lost to climate change	A5: Creation options will concentrate on those habitats most sensitive to climate change (to compensate for projected losses)	HC10	Creation of woodland outside of the SDA & ML
			HC14	Creation of wood pasture
			HC17	Creation of successional areas and scrub
			HC21	Creation of traditional orchards
			HC9	Creation of woodland in the SDA
			HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK8	Creation of species-rich, semi-natural grassland
			HL11	Creation of upland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP7	Creation of inter-tidal and saline habitat on arable land

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HP8	Creation of inter-tidal and saline habitat on grassland
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ5	Creation of reedbeds
			HQ8	Creation of fen
			WCG	Woodland Creation Grant
Valuing the wider adaptation benefits	Identify opportunities for Ecosystem-based Adaptation	A6: Agri-environment management will create shade for rivers where this is a priority for the freshwater habitat	EC23	Establishment of hedgerow trees by tagging
			EC4	Management of woodland edges
			HC10	Creation of woodland outside of the SDA & ML
			HC11	Woodland livestock exclusion supplement
			HC4	Management of woodland edges
			HC5	Ancient trees in arable fields
			HC6	Ancient trees in intensively-managed grass fields
			HC7	Maintenance of woodland
			HC8	Restoration of woodland
			HC9	Creation of woodland in the SDA
			OC23	Establishment of hedgerow trees by tagging
			OC3	Maintenance of woodland fences
			OC4	Management of wood edges
			OHC4	Management of woodland edges
			UC22	Woodland livestock exclusion
			UC5	Sheep fencing around small woodlands
			UHC22	Woodland livestock exclusion
			UOC22	Woodland livestock exclusion
			UOC5	Sheep fencing around small woodlands
			WCG	Woodland Creation Grant
			WMG	Woodland Management Grant
			WRG	Woodland Regeneration Grant
Building ecological resilience	Non-climatic adverse pressures will be reduced	B1: Creation options will reduce fragmentation	HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK8	Creation of species-rich, semi-natural grassland
			HL11	Creation of upland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP7	Creation of inter-tidal and saline habitat on arable land
			HP8	Creation of inter-tidal and saline habitat on grassland
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ5	Creation of reedbeds
			HQ8	Creation of fen
Building ecological resilience	Non-climatic adverse pressures will be reduced	B2: Restoration options will support the reduction of fragmentation	HK7	Restoration of species-rich, semi-natural grassland
			HL10	Restoration of moorland
			HO2	Restoration of lowland heath
			HO3	Restoration of forestry areas to lowland heathland
			HP2	Restoration of sand dune systems
			HQ10	Restoration of lowland raised bog
			HQ4	Restoration of reedbeds
Building ecological resilience	Action should focus on the best sites	B4: Woodland restoration and maintenance options will support the reduction of woodland fragmentation	HC12	Maintenance of wood pasture and parkland
			HC13	Restoration of wood pasture and parkland
			HC15	Maintenance of successional areas and scrub
			HC16	Restoration of successional areas and scrub
			HC18	Maintenance of high value traditional orchards
			HC19	Maintenance of traditional orchards in production
			HC20	Restoration of traditional orchards
			HC5	Ancient trees in arable fields
			HC6	Ancient trees in intensively-managed grass fields
			HC7	Maintenance of woodland
			HC8	Restoration of woodland
			OC3	Maintenance of woodland fences
			UC5	Sheep fencing around small woodlands
			UOC5	Sheep fencing around small woodlands

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
Accommodating change	Agri-environment schemes should promote the dispersal between fragmented patches	B5: Matrix options to restore or create features should be focussed in areas of high fragmentation	EB14	Hedgerow restoration
			EC24	Hedgerow tree buffer strips on cultivated land
			EC25	Hedgerow tree buffer strips on grassland
			EE1	2m buffer strips on cultivated land
			EE10	6m buffer strips on intensive grassland next to a watercourse
			EE2	4m buffer strips on cultivated land
			EE3	6m buffer strips on cultivated land
			EE4	2m buffer strips on intensive grassland
			EE5	4m buffer strips on intensive grassland
			EE6	6m buffer strips on intensive grassland
			EE7	Buffering in-field ponds in improved grassland
			EE8	Buffering in-field ponds in arable land
			EE9	6m buffer strips on cultivated land next to a watercourse
			EF1	Field corner management
			EF10	Unharvested cereal headlands for birds and rare arable plants
			EF11	Uncropped, cultivated margins for rare plants on arable land
			EF13	Uncropped cultivated areas for ground-nesting birds - arable
			EF15	Reduced herbicide cereal crop preceding over-wintered stubble
			EF2	Wild bird seed mixture
			EF22	Extended overwintered stubbles
			EF3	ASD to Dec 2008 Wild bird seed mixture on set-aside land
			EF4	Nectar Flower mixture
			EF5	ASD to Dec 2008 Pollen + nectar flower mixture on set-aside land
			EF6	Over-wintered stubbles
			EF7	Beetle banks
			EF8	Skylark plots
			EF9	Cereal headlands for birds
			EG1	Under sown spring cereals
			EG2	ASD to Jan 2010 Wild bird seed mixture in grassland areas
			EG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			EG4	Cereals for whole crop silage followed by over-wintered stubbles
			EG5	Brassica fodder crops followed by over-wintered stubbles
			EJ9	12m buffer strips for watercourses on cultivated land
			EK1	Take field corners out of management: outside SDA & ML
			EK20	Ryegrass seed-set as winter/spring food for birds
			EK21	Legume- and herb-rich swards
			EL1	Field corner management: SDA land
			HC24	Hedgerow tree buffer strips on cultivated land
			HC25	Hedgerow tree buffer strips on grassland
			HE1	2 m buffer strips on cultivated land
			HE10	Floristically enhanced grass margin
			HE11	Enhanced strips for target species on intensive grassland
			HE2	4 m buffer strips on cultivated land
			HE3	6 m buffer strips on cultivated land
			HE4	2 m buffer strips on intensive grassland
			HE5	4 m buffer strips on intensive grassland
			HE6	6 m buffer strips on intensive grassland
			HE7	Buffering in-field ponds in improved permanent grassland
			HE8	Buffering in-field ponds in arable land
			HF1	Management of field corners
			HF10	Unharvested cereal headlands for birds and rare arable plants
			HF11	Uncropped, cultivated margins for rare plants
			HF12	Enhanced wild bird seed mix plots
			HF13	Uncropped cultivated areas for ground-nesting birds - arable
			HF14	Unharvested, fertiliser-free conservation headland
			HF15	Reduced herbicide cereal crops followed by overwintered stubble
			HF16	ASD to Dec 2008 Cultivated area for arable flora on setaside
			HF17	ASD to Dec 2008 Fallow plots for ground-nesting birds (setaside)
			HF18	ASD to Dec 2008 Reduced herbicide cereal crop preceding setaside
			HF19	ASD to Dec 2008 Unharvested conservation headland with setaside
			HF2	Wild bird seed mixture
			HF20	Cultivated fallow plots or margins for arable plants
			HF3	ASD to Dec 2008 Wild bird seed mixture on set-aside land

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HF4	Nectar flower mixture
			HF5	ASD to Dec 2008 Pollen & nectar flower mixture on set-aside land
			HF6	Overwintered stubble
			HF7	Beetle banks
			HF8	Skylark plots
			HF9	Cereal headlands for birds
			HG1	Under sown spring cereals
			HG2	ASD to Jan 2010 Wild bird seed mixture
			HG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			HG4	Cereals for whole-crop silage followed by overwintered stubble
			HG5	Brassica fodder crops followed by over-wintered stubbles
			HG6	Fodder crop management to retain or re-create an arable mosaic
			HG7	Low input spring cereal to retain or re-create an arable mosaic
			HK1	Take field corners out of management
			HK16	Restoration of grassland for target features
			HK17	Creation of grassland for target features
			HK20	Ryegrass seed-set as winter/spring food for birds
			HK21	Legume- and herb-rich swards
			HL1	Take field corners out of management in SDAs
			HL6	Unenclosed moorland rough grazing
			HL8	Restoration of rough grazing for birds
			OB14	Hedgerow restoration
			OE1	2m buffer strips on rotational land
			OE10	6m buffer strip on organic grassland next to a watercourse
			OE2	4m buffer strips on rotational land
			OE3	6m buffer strips on rotational land
			OE4	2m buffer strip on organic grassland
			OE5	4m buffer strip on organic grassland
			OE6	6m buffer strip on organic grassland
			OE7	Buffering in-field ponds in organic grassland
			OE8	Buffering in-field ponds in rotational land
			OE9	6m buffer strips on rotational land next to a watercourse
			OF1	Field corner management
			OF11	Uncropped, cultivated margins for rare plants on arable land
			OF13	Uncropped cultivated areas for ground-nesting birds - rotational
			OF2	Wild bird seed mixture
			OF4	Nectar Flower mixture
			OF6	Over-wintered stubbles
			OF7	Beetle banks
			OF8	Skylark plots
			OG1	Under sown spring cereals
			OG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			OG4	Cereals for whole crop silage followed by over-wintered stubbles
			OG5	Brassica fodder crops followed by over-wintered stubbles
			OHE1	2 m buffer strips on rotational land
			OHE2	4 m buffer strips on rotational land
			OHE3	6 m buffer strips on rotational land
			OHE4	2 m buffer strips on organic grassland
			OHE5	4 m buffer strips on organic grassland
			OHE6	6 m buffer strips on organic grassland
			OHE7	Buffering in-field ponds in organic grassland
			OHE8	Buffering in-field ponds in rotational land
			OHF1	Management of field corners
			OHF11	Uncropped, cultivated margins for rare plants
			OHF13	Uncropped, cultivated areas for ground-nesting birds
			OHF2	Wild bird seed mixture
			OHF4	Nectar flower mixture
			OHF6	Overwintered stubble
			OHF7	Beetle banks
			OHF8	Skylark plots
			OHG1	Under sown spring cereals
			OHG2	ASD to Jan 2010 Wild bird seed mix in grassland areas (organic)
			OHG3	ASD to Jan 2010 Nectar flower mixture in grassland areas

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			OHG4	Cereals for whole-crop silage followed by overwintered stubble
			OHG5	Brassica fodder crops followed by over-wintered stubbles (org)
			OHK1	Take field corners out of management
			OHK20	Ryegrass seed-set as winter/spring food for birds
			OHK21	Legume- and herb-rich swards
			OK1	Take field corners out of management: outside SDA & ML(organic)
			OK21	Legume- and herb-rich swards
			OL1	Field corner management: SDA land(organic)
			UB14	Hedgerow restoration
			UB15	Stone-faced hedge bank restoration
			UB16	Earth bank restoration
			UHL21	No cutting strip within meadows
			UL21	No cutting strip within meadows
			UOB14	Hedgerow restoration
			UOB15	Stone-faced hedge bank restoration
			UOB16	Earth bank restoration
			UOL21	No cutting strip within meadows
Building ecological resilience	Non-climatic adverse pressures will be reduced	B6: Creation options will enhance ecological networks	HC10	Creation of woodland outside of the SDA & ML
			HC14	Creation of wood pasture
			HC17	Creation of successional areas and scrub
			HC21	Creation of traditional orchards
			HC9	Creation of woodland in the SDA
			HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK8	Creation of species-rich, semi-natural grassland
			HL11	Creation of upland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP7	Creation of inter-tidal and saline habitat on arable land
			HP8	Creation of inter-tidal and saline habitat on grassland
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ5	Creation of reedbeds
			HQ8	Creation of fen
			WCG	Woodland Creation Grant
Building ecological resilience	Action should focus on the best sites	B7: Woodland creation under agri-environment schemes will fall within or extend existing functional networks for woodland species	HC10	Creation of woodland outside of the SDA & ML
			HC14	Creation of wood pasture
			HC17	Creation of successional areas and scrub
			HC21	Creation of traditional orchards
			HC9	Creation of woodland in the SDA
			WCG	Woodland Creation Grant
Building ecological resilience	Action should focus on areas likely to remain less impacted by climate change	C1: Creation, restoration and maintenance of habitats will be focused on areas with high potential to provide refugia	HC10	Creation of woodland outside of the SDA & ML
			HC12	Maintenance of wood pasture and parkland
			HC13	Restoration of wood pasture and parkland
			HC14	Creation of wood pasture
			HC15	Maintenance of successional areas and scrub
			HC16	Restoration of successional areas and scrub
			HC17	Creation of successional areas and scrub
			HC18	Maintenance of high value traditional orchards
			HC19	Maintenance of traditional orchards in production
			HC20	Restoration of traditional orchards
			HC21	Creation of traditional orchards
			HC7	Maintenance of woodland
			HC8	Restoration of woodland
			HC9	Creation of woodland in the SDA
			HK10	Maintenance of wet grassland for wintering waders and wildfowl
			HK11	Restoration of wet grassland for breeding waders.
			HK12	Restoration of wet grassland for wintering waders and wildfowl

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK6	Maintenance of species-rich, semi-natural grassland
			HK7	Restoration of species-rich, semi-natural grassland
			HK8	Creation of species-rich, semi-natural grassland
			HK9	Maintenance of wet grassland for breeding waders
			HL10	Restoration of moorland
			HL11	Creation of upland heathland
			HL9	Maintenance of moorland
			HO1	Maintenance of lowland heathland
			HO2	Restoration of lowland heath
			HO3	Restoration of forestry areas to lowland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites
			HP1	Maintenance of sand dunes
			HP2	Restoration of sand dune systems
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP5	Maintenance of coastal saltmarsh
			HP6	Restoration of coastal saltmarsh
			HP7	Creation of inter-tidal and saline habitat on arable land
			HP8	Creation of inter-tidal and saline habitat on grassland
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ1	Maintenance of ponds of high wildlife value < 100 sq m
			HQ10	Restoration of lowland raised bog
			HQ2	Maintenance of ponds of high wildlife value > 100 sq m
			HQ3	Maintenance of reedbeds
			HQ4	Restoration of reedbeds
			HQ5	Creation of reedbeds
			HQ6	Maintenance of fen
			HQ7	Restoration of fen
			HQ8	Creation of fen
			HQ9	Maintenance of lowland raised bog
			WCG	Woodland Creation Grant
			WMG	Woodland Management Grant
			WRG	Woodland Regeneration Grant
Accommodating change	Environmental goals and targeting will reflect environmental change	D1: Agri-environment scheme options will be coincident with priority areas for conserving biodiversity under projected future climatic conditions	HC10	Creation of woodland outside of the SDA & ML
			HC12	Maintenance of wood pasture and parkland
			HC13	Restoration of wood pasture and parkland
			HC14	Creation of wood pasture
			HC15	Maintenance of successional areas and scrub
			HC16	Restoration of successional areas and scrub
			HC17	Creation of successional areas and scrub
			HC18	Maintenance of high value traditional orchards
			HC19	Maintenance of traditional orchards in production
			HC20	Restoration of traditional orchards
			HC21	Creation of traditional orchards
			HC7	Maintenance of woodland
			HC8	Restoration of woodland
			HC9	Creation of woodland in the SDA
			HK10	Maintenance of wet grassland for wintering waders and wildfowl
			HK11	Restoration of wet grassland for breeding waders.
			HK12	Restoration of wet grassland for wintering waders and wildfowl
			HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK6	Maintenance of species-rich, semi-natural grassland
			HK7	Restoration of species-rich, semi-natural grassland
			HK8	Creation of species-rich, semi-natural grassland
			HK9	Maintenance of wet grassland for breeding waders
			HL10	Restoration of moorland
			HL11	Creation of upland heathland
			HL9	Maintenance of moorland
			HO1	Maintenance of lowland heathland

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HO2	Restoration of lowland heath
			HO3	Restoration of forestry areas to lowland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites
			HP1	Maintenance of sand dunes
			HP2	Restoration of sand dune systems
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP5	Maintenance of coastal saltmarsh
			HP6	Restoration of coastal saltmarsh
			HP7	Creation of inter-tidal and saline habitat on arable land
			HP8	Creation of inter-tidal and saline habitat on grassland
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ1	Maintenance of ponds of high wildlife value < 100 sq m
			HQ10	Restoration of lowland raised bog
			HQ2	Maintenance of ponds of high wildlife value > 100 sq m
			HQ3	Maintenance of reedbeds
			HQ4	Restoration of reedbeds
			HQ5	Creation of reedbeds
			HQ6	Maintenance of fen
			HQ7	Restoration of fen
			HQ8	Creation of fen
			HQ9	Maintenance of lowland raised bog
			WCG	Woodland Creation Grant
			WMG	Woodland Management Grant
			WRG	Woodland Regeneration Grant
Accommodating change	Action should accommodate change	D2: Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations	EB14	Hedgerow restoration
			EC23	Establishment of hedgerow trees by tagging
			EC24	Hedgerow tree buffer strips on cultivated land
			EC25	Hedgerow tree buffer strips on grassland
			EC4	Management of woodland edges
			EE1	2m buffer strips on cultivated land
			EE10	6m buffer strips on intensive grassland next to a watercourse
			EE2	4m buffer strips on cultivated land
			EE3	6m buffer strips on cultivated land
			EE4	2m buffer strips on intensive grassland
			EE5	4m buffer strips on intensive grassland
			EE6	6m buffer strips on intensive grassland
			EE7	Buffering in-field ponds in improved grassland
			EE8	Buffering in-field ponds in arable land
			EE9	6m buffer strips on cultivated land next to a watercourse
			EF1	Field corner management
			EF10	Unharvested cereal headlands for birds and rare arable plants
			EF11	Uncropped, cultivated margins for rare plants on arable land
			EF13	Uncropped cultivated areas for ground-nesting birds - arable
			EF15	Reduced herbicide cereal crop preceding over-wintered stubble
			EF2	Wild bird seed mixture
			EF22	Extended overwintered stubbles
			EF2NR	Wild bird seed mixture
			EF3	ASD to Dec 2008 Wild bird seed mixture on set-aside land
			EF4	Nectar Flower mixture
			EF4NR	Nectar Flower mixture
			EF5	ASD to Dec 2008 Pollen + nectar flower mixture on set-aside land
			EF6	Over-wintered stubbles
			EF7	Beetle banks
			EF8	Skylark plots
			EF9	Cereal headlands for birds
			EG1	Under sown spring cereals
			EG2	ASD to Jan 2010 Wild bird seed mixture in grassland areas
			EG2NR	ASD to Jan 2010 Wild bird seed mixture in grassland areas
			EG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			EG4	Cereals for whole crop silage followed by over-wintered stubbles
			EG5	Brassica fodder crops followed by over-wintered stubbles

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			EJ9	12m buffer strips for watercourses on cultivated land
			EK1	Take field corners out of management: outside SDA & ML
			EK20	Ryegrass seed-set as winter/spring food for birds
			EK21	Legume- and herb-rich swards
			EL1	Field corner management: SDA land
			HC24	Hedgerow tree buffer strips on cultivated land
			HC25	Hedgerow tree buffer strips on grassland
			HC4	Management of woodland edges
			HE1	2 m buffer strips on cultivated land
			HE10	Floristically enhanced grass margin
			HE11	Enhanced strips for target species on intensive grassland
			HE2	4 m buffer strips on cultivated land
			HE3	6 m buffer strips on cultivated land
			HE4	2 m buffer strips on intensive grassland
			HE5	4 m buffer strips on intensive grassland
			HE6	6 m buffer strips on intensive grassland
			HE7	Buffering in-field ponds in improved permanent grassland
			HE8	Buffering in-field ponds in arable land
			HF1	Management of field corners
			HF10	Unharvested cereal headlands for birds and rare arable plants
			HF10NR	Unharvested cereal headlands for birds and rare arable plants
			HF11	Uncropped, cultivated margins for rare plants
			HF12	Enhanced wild bird seed mix plots
			HF12NR	Enhanced wild bird seed mix plots
			HF13	Uncropped cultivated areas for ground-nesting birds - arable
			HF13NR	Uncropped cultivated areas for ground-nesting birds - arable
			HF14	Unharvested, fertiliser-free conservation headland
			HF14NR	Unharvested, fertiliser-free conservation headland
			HF15	Reduced herbicide cereal crops followed by overwintered stubble
			HF15NR	Reduced herbicide cereal crops following overwintered stubble
			HF16	ASD to Dec 2008 Cultivated area for arable flora on setaside
			HF17	ASD to Dec 2008 Fallow plots for ground-nesting birds (setaside)
			HF18	ASD to Dec 2008 Reduced herbicide cereal crop preceding setaside
			HF19	ASD to Dec 2008 Unharvested conservation headland with setaside
			HF2	Wild bird seed mixture
			HF20	Cultivated fallow plots or margins for arable plants
			HF20NR	Cultivated fallow plots or margins for arable plants
			HF2NR	Wild bird seed mixture
			HF3	ASD to Dec 2008 Wild bird seed mixture on set-aside land
			HF4	Nectar flower mixture
			HF4NR	Nectar flower mixture
			HF5	ASD to Dec 2008 Pollen & nectar flower mixture on set-aside land
			HF6	Overwintered stubble
			HF7	Beetle banks
			HF8	Skylark plots
			HF9	Cereal headlands for birds
			HF9NR	Cereal headlands for birds
			HG1	Under sown spring cereals
			HG2	ASD to Jan 2010 Wild bird seed mixture
			HG2NR	ASD to Jan 2010 Wild bird seed mixture
			HG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			HG4	Cereals for whole-crop silage followed by overwintered stubble
			HG5	Brassica fodder crops followed by over-wintered stubbles
			HG6	Fodder crop management to retain or re-create an arable mosaic
			HG6NR	Fodder crop management to retain or re-create an arable mosaic
			HG7	Low input spring cereal to retain or re-create an arable mosaic
			HG7NR	Low input spring cereal to retain or re-create an arable mosaic
			HK1	Take field corners out of management
			HK11	Restoration of wet grassland for breeding waders.
			HK12	Restoration of wet grassland for wintering waders and wildfowl
			HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK16	Restoration of grassland for target features

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HK17	Creation of grassland for target features
			HK20	Ryegrass seed-set as winter/spring food for birds
			HK21	Legume- and herb-rich swards
			HL1	Take field corners out of management in SDAs
			HL6	Unenclosed moorland rough grazing
			HL8	Restoration of rough grazing for birds
			OB14	Hedgerow restoration
			OC23	Establishment of hedgerow trees by tagging
			OC24	Hedgerow tree buffer strips on rotational land
			OC25	Hedgerow tree buffer strips on organic grassland
			OC4	Management of wood edges
			OE1	2m buffer strips on rotational land
			OE10	6m buffer strip on organic grassland next to a watercourse
			OE2	4m buffer strips on rotational land
			OE3	6m buffer strips on rotational land
			OE4	2m buffer strip on organic grassland
			OE5	4m buffer strip on organic grassland
			OE6	6m buffer strip on organic grassland
			OE7	Buffering in-field ponds in organic grassland
			OE8	Buffering in-field ponds in rotational land
			OE9	6m buffer strips on rotational land next to a watercourse
			OF1	Field corner management
			OF11	Uncropped, cultivated margins for rare plants on arable land
			OF13	Uncropped cultivated areas for ground-nesting birds - rotational
			OF2	Wild bird seed mixture
			OF2NR	Wild bird seed mixture
			OF4	Nectar Flower mixture
			OF4NR	Nectar Flower mixture
			OF6	Over-wintered stubbles
			OF7	Beetle banks
			OF8	Skylark plots
			OG1	Under sown spring cereals
			OG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			OG4	Cereals for whole crop silage followed by over-wintered stubbles
			OG5	Brassica fodder crops followed by over-wintered stubbles
			OHC24	Hedgerow tree buffer strips on rotational land
			OHE1	2 m buffer strips on rotational land
			OHE2	4 m buffer strips on rotational land
			OHE3	6 m buffer strips on rotational land
			OHE4	2 m buffer strips on organic grassland
			OHE5	4 m buffer strips on organic grassland
			OHE6	6 m buffer strips on organic grassland
			OHE7	Buffering in-field ponds in organic grassland
			OHE8	Buffering in-field ponds in rotational land
			OHF1	Management of field corners
			OHF11	Uncropped, cultivated margins for rare plants
			OHF13	Uncropped, cultivated areas for ground-nesting birds
			OHF13NR	Uncropped, cultivated areas for ground-nesting birds
			OHF2	Wild bird seed mixture
			OHF2NR	Wild bird seed mixture
			OHF4	Nectar flower mixture
			OHF4NR	Nectar flower mixture
			OHF6	Overwintered stubble
			OHF7	Beetle banks
			OHF8	Skylark plots
			OHG1	Under sown spring cereals
			OHG2	ASD to Jan 2010 Wild bird seed mix in grassland areas (organic)
			OHG2NR	ASD to Jan 2010 Wild bird seed mix in grassland areas (organic)
			OHG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			OHG4	Cereals for whole-crop silage followed by overwintered stubble
			OHG5	Brassica fodder crops followed by over-wintered stubbles (org)

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			OHK1	Take field corners out of management
			OHK20	Ryegrass seed-set as winter/spring food for birds
			OHK21	Legume- and herb-rich swards
			OK1	Take field corners out of management: outside SDA & ML(organic)
			OK21	Legume- and herb-rich swards
			OL1	Field corner management: SDA land(organic)
			UB14	Hedgerow restoration
			UB15	Stone-faced hedge bank restoration
			UB16	Earth bank restoration
			UHL21	No cutting strip within meadows
			UL21	No cutting strip within meadows
			UOB14	Hedgerow restoration
			UOB15	Stone-faced hedge bank restoration
			UOB16	Earth bank restoration
			UOL21	No cutting strip within meadows
Accommodating change	Action should accommodate change	D2: Agri-environment scheme options will be targeted and applied appropriately to reflect likely species turnover in different locations (restoration and maintenance options)	HC12	Maintenance of wood pasture and parkland
			HC13	Restoration of wood pasture and parkland
			HC15	Maintenance of successional areas and scrub
			HC16	Restoration of successional areas and scrub
			HC18	Maintenance of high value traditional orchards
			HC19	Maintenance of traditional orchards in production
			HC20	Restoration of traditional orchards
			HC7	Maintenance of woodland
			HC8	Restoration of woodland
			HK10	Maintenance of wet grassland for wintering waders and wildfowl
			HK11	Restoration of wet grassland for breeding waders.
			HK12	Restoration of wet grassland for wintering waders and wildfowl
			HK6	Maintenance of species-rich, semi-natural grassland
			HK7	Restoration of species-rich, semi-natural grassland
			HK9	Maintenance of wet grassland for breeding waders
			HL10	Restoration of moorland
			HL9	Maintenance of moorland
			HO1	Maintenance of lowland heathland
			HO2	Restoration of lowland heath
			HO3	Restoration of forestry areas to lowland heathland
			HP1	Maintenance of sand dunes
			HP2	Restoration of sand dune systems
			HP5	Maintenance of coastal saltmarsh
			HP6	Restoration of coastal saltmarsh
			HQ1	Maintenance of ponds of high wildlife value < 100 sq m
			HQ10	Restoration of lowland raised bog
			HQ2	Maintenance of ponds of high wildlife value > 100 sq m
			HQ3	Maintenance of reedbeds
			HQ4	Restoration of reedbeds
			HQ6	Maintenance of fen
			HQ7	Restoration of fen
			HQ9	Maintenance of lowland raised bog
			WMG	Woodland Management Grant
			WRG	Woodland Regeneration Grant
Building ecological resilience	Restore degraded ecosystems	E1: Creation and restoration options will be focused within areas supporting the Outcome 1D objective	HK7	Restoration of species-rich, semi-natural grassland
			HK8	Creation of species-rich, semi-natural grassland
			HL10	Restoration of moorland
			HL11	Creation of upland heathland
			HO2	Restoration of lowland heath
			HO3	Restoration of forestry areas to lowland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites
			HP2	Restoration of sand dune systems
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP6	Restoration of coastal saltmarsh
			HP7	Creation of inter-tidal and saline habitat on arable land
			HP8	Creation of inter-tidal and saline habitat on grassland

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ10	Restoration of lowland raised bog
			HQ4	Restoration of reedbeds
			HQ5	Creation of reedbeds
			HQ7	Restoration of fen
			HQ8	Creation of fen
Building ecological resilience	Agri-environment schemes should build the resilience of populations	F1: Creation options around existing semi-natural areas will create larger conservation sites	HC10	Creation of woodland outside of the SDA & ML
			HC14	Creation of wood pasture
			HC17	Creation of successional areas and scrub
			HC21	Creation of traditional orchards
			HC9	Creation of woodland in the SDA
			HK8	Creation of species-rich, semi-natural grassland
			HL11	Creation of upland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP7	Creation of inter-tidal and saline habitat on arable land
			HP8	Creation of inter-tidal and saline habitat on grassland
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ5	Creation of reedbeds
			HQ8	Creation of fen
			WCG	Woodland Creation Grant
Building Ecological Resilience	Increase the heterogeneity of patches	F2: Creation options increase the topographic heterogeneity of habitats	No relevant options data available/relevant at this scale.	
Valuing the wider adaptation benefits	Agri-environment schemes should promote Ecosystem-based Adaptation	G1: Matrix options for soil protection will be focused in Water Quality Priority Areas	EE10	6m buffer strips on intensive grassland next to a watercourse
			EE2	4m buffer strips on cultivated land
			EE3	6m buffer strips on cultivated land
			EE5	4m buffer strips on intensive grassland
			EE6	6m buffer strips on intensive grassland
			EE7	Buffering in-field ponds in improved grassland
			EE8	Buffering in-field ponds in arable land
			EE9	6m buffer strips on cultivated land next to a watercourse
			EF15	Reduced herbicide cereal crop preceding over-wintered stubble
			EF22	Extended overwintered stubbles
			EF4	Nectar Flower mixture
			EF4NR	Nectar Flower mixture
			EF5	ASD to Dec 2008 Pollen + nectar flower mixture on set-aside land
			EF6	Over-wintered stubbles
			EF7	Beetle banks
			EG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			EG4	Cereals for whole crop silage followed by over-wintered stubbles
			EG5	Brassica fodder crops followed by over-wintered stubbles
			EJ10	Enhanced management of maize crops to reduce erosion and run-off
			EJ13	Winter cover crops
			EJ5	In-field grass areas
			EJ9	12m buffer strips for watercourses on cultivated land
			EK1	Take field corners out of management: outside SDA & ML
			EK21	Legume- and herb-rich swards
			EK3	Permanent grassland with very low inputs: outside SDA & ML
			HB14	Management of ditches of very high environmental value
			HC10	Creation of woodland outside of the SDA & ML
			HC14	Creation of wood pasture
			HC17	Creation of successional areas and scrub
			HC9	Creation of woodland in the SDA
			HE2	4 m buffer strips on cultivated land
			HE3	6 m buffer strips on cultivated land
			HE5	4 m buffer strips on intensive grassland
			HE6	6 m buffer strips on intensive grassland

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HE7	Buffering in-field ponds in improved permanent grassland
			HE8	Buffering in-field ponds in arable land
			HF15	Reduced herbicide cereal crops followed by overwintered stubble
			HF15NR	Reduced herbicide cereal crops following overwintered stubble
			HF4	Nectar flower mixture
			HF4NR	Nectar flower mixture
			HF5	ASD to Dec 2008 Pollen & nectar flower mixture on set-aside land
			HF6	Overwintered stubble
			HF7	Beetle banks
			HG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			HG4	Cereals for whole-crop silage followed by overwintered stubble
			HG5	Brassica fodder crops followed by over-wintered stubbles
			HJ10	Enhanced management of maize crops to reduce erosion and run-off
			HJ13	Winter cover crops
			HJ3	Reversion to unfertilised grassland to prevent erosion/run-off
			HJ4	Reversion to low input grassland to prevent erosion/run-off
			HJ5	In-field grass areas to prevent erosion or run-off
			HJ6	Preventing erosion or run-off from intensively managed grassland
			HJ7	Seasonal livestock removal from intensively managed grassland
			HJ8	Nil fertiliser supplement
			HJ9	12 m buffer strips for watercourses on cultivated land
			HK1	Take field corners out of management
			HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK17	Creation of grassland for target features
			HK21	Legume- and herb-rich swards
			HK3	Permanent grassland with very low inputs
			HL1	Take field corners out of management in SDAs
			HL15	Seasonal livestock exclusion supplement
			HO4	Creation of lowland heathland from arable or improved grassland
			HQ1	Maintenance of ponds of high wildlife value < 100 sq m
			HQ2	Maintenance of ponds of high wildlife value > 100 sq m
			HQ5	Creation of reedbeds
			HQ8	Creation of fen
			OE10	6m buffer strip on organic grassland next to a watercourse
			OE2	4m buffer strips on rotational land
			OE3	6m buffer strips on rotational land
			OE5	4m buffer strip on organic grassland
			OE6	6m buffer strip on organic grassland
			OE7	Buffering in-field ponds in organic grassland
			OE8	Buffering in-field ponds in rotational land
			OE9	6m buffer strips on rotational land next to a watercourse
			OF4	Nectar Flower mixture
			OF4NR	Nectar Flower mixture
			OF6	Over-wintered stubbles
			OF7	Beetle banks
			OG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			OG4	Cereals for whole crop silage followed by over-wintered stubbles
			OG5	Brassica fodder crops followed by over-wintered stubbles
			OHE2	4 m buffer strips on rotational land
			OHE3	6 m buffer strips on rotational land
			OHE5	4 m buffer strips on organic grassland
			OHE6	6 m buffer strips on organic grassland
			OHE7	Buffering in-field ponds in organic grassland
			OHE8	Buffering in-field ponds in rotational land
			OHF4	Nectar flower mixture
			OHF4NR	Nectar flower mixture
			OHF6	Overwintered stubble
			OHF7	Beetle banks
			OHG3	ASD to Jan 2010 Nectar flower mixture in grassland areas
			OHG4	Cereals for whole-crop silage followed by overwintered stubble
			OHG5	Brassica fodder crops followed by over-wintered stubbles (org)
			OHJ13	Winter cover crops

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			OHJ5	In-field grass areas to prevent erosion and run-off
			OHJ9	12 m buffer strips for watercourses on rotational land
			OHK1	Take field corners out of management
			OHK21	Legume- and herb-rich swards
			OHK3	Permanent grassland with very low inputs
			OJ13	Winter cover crops
			OJ5	In-field grass areas to prevent erosion or run-off
			OJ9	12m buffer strips for watercourses on cultivated land
			OK1	Take field corners out of management: outside SDA & ML(organic)
			OK21	Legume- and herb-rich swards
			OK3	Permanent grassland with very low inputs: outside SDA&ML(organic)
			OL1	Field corner management: SDA land(organic)
			UJ12	Winter livestock removal next to streams, rivers and lakes
			UOJ12	Winter livestock removal next to streams, rivers and lakes
			WCG	Woodland Creation Grant
Valuing the wider adaptation benefits	Action should accommodate change	G2: There will be a greater concentration of relevant agri-environment schemes options within flood prone areas to reduce flood risk	HL13	Moorland re-wetting supplement
			HP1	Maintenance of sand dunes
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP5	Maintenance of coastal saltmarsh
			HP6	Restoration of coastal saltmarsh
			HP7	Creation of inter-tidal and saline habitat on arable land
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ6	Maintenance of fen
			HQ7	Restoration of fen
Valuing the wider adaptation benefits	Identify opportunities for Ecosystem-Based Mitigation	H1: Agri-environment schemes contribute to the storage and sequestration of carbon	HK10	Maintenance of wet grassland for wintering waders and wildfowl
			HK11	Restoration of wet grassland for breeding waders.
			HK12	Restoration of wet grassland for wintering waders and wildfowl
			HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK6	Maintenance of species-rich, semi-natural grassland
			HK7	Restoration of species-rich, semi-natural grassland
			HK8	Creation of species-rich, semi-natural grassland
			HK9	Maintenance of wet grassland for breeding waders
			HL10	Restoration of moorland
			HL11	Creation of upland heathland
			HL9	Maintenance of moorland
			HO1	Maintenance of lowland heathland
			HO2	Restoration of lowland heath
			HO3	Restoration of forestry areas to lowland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites
			HQ1	Maintenance of ponds of high wildlife value < 100 sq m
			HQ10	Restoration of lowland raised bog
			HQ2	Maintenance of ponds of high wildlife value > 100 sq m
			HQ3	Maintenance of reedbeds
			HQ4	Restoration of reedbeds
			HQ5	Creation of reedbeds
			HQ6	Maintenance of fen
			HQ7	Restoration of fen
			HQ8	Creation of fen
			HQ9	Maintenance of lowland raised bog
Valuing the wider adaptation benefits	Targeting and applying interventions in a cost-effective and adaptive way	I1: Adaptation in the natural environment will be consistent with agricultural adaptation.	HC10	Creation of woodland outside of the SDA & ML
			HC14	Creation of wood pasture
			HC17	Creation of successional areas and scrub
			HC21	Creation of traditional orchards
			HC9	Creation of woodland in the SDA
			HK13	Creation of wet grassland for breeding waders
			HK14	Creation of wet grassland for wintering waders and wildfowl
			HK8	Creation of species-rich, semi-natural grassland
			HL11	Creation of upland heathland
			HO4	Creation of lowland heathland from arable or improved grassland
			HO5	Creation of lowland heathland on worked mineral sites

NAP objective	Adaptation principle	Adaptation indicator	Option code	Description
			HP3	Creation of vegetated shingle and sand dune on arable
			HP4	Creation of vegetated shingle and sand dune on grassland
			HP7	Creation of inter-tidal and saline habitat on arable land
			HP8	Creation of inter-tidal and saline habitat on grassland
			HP9	Creation of inter-tidal and saline habitat by non-intervention
			HQ5	Creation of reedbeds
			HQ8	Creation of fen
			WCG	Woodland Creation Grant
Accommodating change	Improving the flexibility of responses	I2: Options will be implemented in a flexible way to facilitate adaptive management	No relevant options data available/relevant at this scale.	
Accommodating change	Environmental goals and targeting will reflect environmental change	I3: Agri-environment options will accommodate change where appropriate	No relevant options data available/relevant at this scale.	

Appendix E. Results (overflow)

Indicator A1: Maintenance and restoration options will be coincident with priority habitats

Table E-1 Total uptake of individual maintenance and restoration options (and WMG/WRGs) across each priority habitat

	Uptake (ha) of each selected option on each priority habitat type											
Priority habitat	**HC12**	**HC13**	**HC15**	**HC16**	**HC18**	**HC19**	**HC20**	**HC7**	**HC8**	**HK10**	**HK11**	**HK12**
Blanket bog	-	-	57	388	-	-	-	5	68	-	-	-
Calaminarian grassland	-	-	-	-	-	-	-	-	-	-	-	-
Coastal and FGM	177	53	111	24	2	-	3	50	26	15,947	5,057	-
Coastal saltmarsh	-	-	6	3	-	-	-	5	-	189	4	3,348
Coastal sand dunes	-	-	86	9	-	-	-	22	-	25	-	5
Coastal vegetated shingle	-	-	-	12	-	-	-	-	-	3	-	-
Deciduous woodland	1,726	5,374	1,176	680	45	0	37	13,224	9,935	24	7	-
Fragmented heath	-	-	-	-	-	-	-	1	1	-	-	15
Good quality semi-improved grassland	354	227	164	30	1	-	1	111	95	498	198	-
Grass moorland	1	-	14	143	-	-	-	6	1	-	-	56
Limestone pavement	-	17	-	13	-	-	-	2	1	-	-	-
Lowland calcareous grassland	28	54	302	108	0	-	0	246	136	11	-	-
Lowland dry acid grassland	48	27	48	32	-	-	-	55	12	16	73	-
Lowland fens	124	6	116	40	-	-	-	172	109	987	177	-
Lowland heathland	89	1,499	114	31	1	-	0	378	130	1	-	164
Lowland meadows	102	4	27	16	0	-	5	56	33	942	93	-
Lowland raised bog	-	-	10	11	-	-	0	86	63	47	8	107
Maritime cliff and slope	16	-	115	50	-	-	-	80	19	-	-	19
Mountain heaths and willow scrub	-	-	-	-	-	-	-	-	-	-	-	-
Mudflats	-	-	-	-	-	-	-	-	-	-	-	-
No main habitat	2,020	2,651	795	882	20	8	45	839	945	1,411	559	3
Purple moor grass and rush pastures	3	11	26	41	0	-	-	48	17	132	47	385
Reedbeds	-	-	21	3	-	-	-	29	15	71	12	40
Saline lagoons	-	-	2	-	-	-	-	0	-	3	1	-
Traditional orchard	4	4	7	3	560	83	755	36	5	1	-	-
Upland calcareous grassland	-	23	11	110	-	-	-	3	42	-	-	-
Upland flushes, fens and swamps	-	85	11	8	-	-	-	37	16	-	-	-
Upland hay meadow	-	-	1	0	-	-	-	2	5	-	-	-
Upland heathland	-	8	41	274	-	-	-	65	168	-	-	-
Mean	161.8	346.3	112.4	100.4	21.8	3.2	29.2	536.5	408.3	700.3	215.0	-
Min	-	-	-	-	-	-	-	-	-	-	-	143
Max	2,020	5,374	1,176	882	560	83	755	13,224	9,935	15,947	5,057	-
Total	4,693	10,042	3,259	2,911	631	91	847	15,560	11,842	20,307	6,234	3,348
% of total uptake	0.6%	1.2%	0.4%	0.3%	0.1%	0.0%	0.1%	1.8%	1.4%	2.4%	0.7%	4,143

Continued...

	Uptake (ha) of each selected option on each priority habitat type										
Priority habitat	**HK6**	**HK7**	**HK9**	**HL10**	**HL9**	**H01**	**H02**	**HO3**	**HP1**	**HP2**	**HP5**
Blanket bog	17	1	-	173,546	31,213	-	-	-	-	-	-
Calaminarian grassland	5	3	-	75	-	-	-	-	-	-	-
Coastal and FGM	1,164	2,160	10,534	-	-	18	25	-	4	-	420
Coastal saltmarsh	-	10	321	-	-	-	-	-	36	1	10,046
Coastal sand dunes	28	31	11	-	-	65	73	-	1,885	1,533	114
Coastal vegetated shingle	13	-	4	-	-	-	-	-	560	185	-
Deciduous woodland	1,021	2,937	22	391	89	478	4,694	237	-	-	2
Fragmented heath	-	-	-	4,679	-	-	-	-	-	-	-
Good quality semi-improved grassland	2,114	14,273	297	5	0	41	149	4	-	-	33
Grass moorland	160	126	-	7,361	1,493	3	1	-	-	-	-
Limestone pavement	13	15	-	71	-	-	-	-	-	-	-
Lowland calcareous grassland	8,524	12,045	-	181	52	83	2	-	-	-	-
Lowland dry acid grassland	1,481	3,649	-	25	-	610	1,159	9	-	-	5
Lowland fens	444	758	380	183	35	237	1,238	16	139	-	43
Lowland heathland	796	1,431	21	877	404	5,711	24,307	343	-	62	3
Lowland meadows	5,433	2,294	1,547	7	-	-	2	-	-	-	-
Lowland raised bog	16	20	3	24	-	-	34	-	-	-	-
Maritime cliff and slope	320	1,221	6	275	195	293	337	-	3	-	10

	Uptake (ha) of each selected option on each priority habitat type										
Priority habitat	**HK6**	**HK7**	**HK9**	**HL10**	**HL9**	**H01**	**H02**	**HO3**	**HP1**	**HP2**	**HP5**
Mountain heaths and willow scrub	-	-	-	-	-	-	-	-	-	-	-
Mudflats	-	-	-	-	-	-	-	-	-	-	265
No main habitat	2,566	6,154	1,022	62,888	5,343	792	2,720	645	45	8	643
Purple moor grass and rush pastures	1,382	1,800	191	44	-	9	12	-	-	-	-
Reedbeds	8	21	123	-	-	-	1	-	-	-	30
Saline lagoons	-	-	10	-	-	-	-	-	10	-	-
Traditional orchard	19	45	-	-	-	-	-	-	-	-	-
Upland calcareous grassland	440	410	-	6,018	392	-	1	-	-	-	-
Upland flushes, fens and swamps	87	144	-	7,208	568	45	48	-	-	-	-
Upland hay meadow	1,223	390	-	-	-	-	-	-	-	-	-
Upland heathland	11	15	13	133,535	63,548	-	6	-	-	-	-
Mean	941	1,722	500	13,703	3,563	289	1,200	43	92	62	400
Min	-	-	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
Max	8,524	14,273	10,534	173,546	63,548	5,711	24,307	645	1,885	1,533	10,046
Total	27,285	49,951	14,504	397,394	103,332	8,384	34,808	1,253	2,682	1,789	11,612
% of total uptake	3.2%	5.9%	1.7%	46.6%	12.1%	1.0%	4.1%	0.1%	0.3%	0.2%	1.4%

Continued...

	Uptake (ha) of each selected option on each priority habitat type											
Priority habitat	**HP6**	**HQ1**	**HQ10**	**HQ2**	**HQ3**	**HQ4**	**HQ5**	**HQ6**	**HQ7**	**HQ9**	**WMG**	**WRG**
Blanket bog	-	-	-	-	-	-	1	13	-	17	2	-
Calaminarian grassland	-	-	-	-	-	-	-	-	-	-	-	-
Coastal and FGM	50	-	4	-	161	28	351	294	-	-	7	50
Coastal saltmarsh	1,272	-	-	-	188	4	2	-	-	6	-	1,272
Coastal sand dunes	4	-	-	-	2	-	2	4	-	1	-	4
Coastal vegetated shingle	-	-	-	-	-	-	-	-	-	-	-	-
Deciduous woodland	3	-	36	-	49	39	286	378	4	85,197	15,693	3
Fragmented heath	-	-	-	-	-	-	-	-	-	-	0	-
Good quality semi-improved grassland	-	-	-	-	7	3	46	46	2	66	16	-
Grass moorland	-	-	-	-	-	-	-	3	-	29	-	-
Limestone pavement	-	-	-	-	-	-	-	-	-	29	8	-
Lowland calcareous grassland	-	-	-	-	-	-	2	8	-	89	3	-
Lowland dry acid grassland	1	-	-	-	1	-	6	4	0	576	4	1
Lowland fens	-	-	25	-	350	85	1,406	723	12	66	5	-
Lowland heathland	49	-	4	-	5	4	81	59	6	257	16	49
Lowland meadows	-	-	-	-	6	1	24	53	-	26	2	-
Lowland raised bog	-	-	1,544	-	31	-	4	27	312	10	4	-
Maritime cliff and slope	-	-	-	-	-	2	-	-	-	397	1	-
Mountain heaths and willow scrub	-	-	-	-	-	-	-	-	-	-	-	-
Mudflats	-	-	-	-	0	-	-	-	-	0	0	-
No main habitat	57	-	134	-	363	74	215	239	3	3,889	964	57
Purple moor grass and rush pastures	-	-	5	-	3	-	110	79	-	7	0	-
Reedbeds	-	-	-	-	809	80	341	102	-	-	-	-
Saline lagoons	-	-	-	-	13	2	-	-	-	0	-	-
Traditional orchard	0	-	-	-	1	-	-	-	-	5	27	0
Upland calcareous grassland	-	-	-	-	-	-	-	-	-	0	0	-
Upland flushes, fens and swamps	-	-	-	-	-	-	31	1	-	10	2	-
Upland hay meadow	-	-	-	-	-	-	-	-	-	1	-	-
Upland heathland	-	-	-	-	-	-	-	-	-	260	19	-
Mean	49	-	60	-	69	11	100	70	12	3,136	578	49
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Max	1,272	-	1,544	-	809	85	1,406	723	312	85,197	15,693	1,272
Total	1,435	-	1,752	-	1,988	321	2,908	2,031	339	90,936	16,773	1,435
% of total uptake	0.2%	0.0%	0.2%	0.0%	0.2%	0.0%	0.3%	0.2%	0.0%	10.7%	2.0%	0.2%

Table E-2 Total area of UAA, priority habitat and option uptake within each NCA

National Character Area	Total area (ha) of NCA	Total area (ha) of UAA within NCA	Total area (ha) of priority habitat within NCA	Total area (ha) of priority habitat within UAA within NCA	Total area (ha) of priority habitat within the UAA covered by C options	% of priority habitat covered by C options
Arden	143,425	73,102	11,597	5,842	1,924	32.9%
Avon Vale	64,285	49,772	4,013	2,698	1,613	59.8%
Bedfordshire and Cambridgeshire Claylands	260,560	198,919	17,419	12,428	2,693	21.7%
Bedfordshire Greensand Ridge	27,337	19,887	4,621	3,351	1,389	41.4%
Berkshire and Marlborough Downs	110,986	97,187	12,080	9,303	3,371	36.2%
Black Mountains and Golden Valley	25,974	24,318	3,987	3,759	2,048	54.5%
Blackdowns	80,807	66,094	11,244	8,050	3,130	38.9%
Blackmoor Vale and the Vale of Wardour	78,414	67,373	6,757	5,522	4,101	74.3%
Bodmin Moor	28,579	25,630	8,711	8,424	3,981	47.3%
Border Moors and Forests	127,156	67,172	36,404	30,845	24,992	81.0%
Bowland Fells	37,395	35,071	21,561	21,267	18,832	88.6%
Bowland Fringe and Pendle Hill	74,090	66,389	9,482	8,306	3,539	42.6%
Breckland	101,926	70,989	22,800	18,603	6,203	33.3%
Bristol, Avon Valleys and Ridges	84,255	50,488	7,788	4,780	1,848	38.7%
Cannock Chase and Cank Wood	72,791	28,582	8,377	4,824	2,160	44.8%
Carnmenellis	14,328	10,573	1,000	559	72	12.9%
Central Lincolnshire Vale	81,898	71,028	5,661	3,328	1,122	33.7%
Central North Norfolk	72,035	55,625	8,714	5,893	2,236	38.0%
Charnwood	17,464	10,359	2,720	1,547	707	45.7%
Cheshire Sandstone Ridge	22,042	16,101	2,256	1,299	706	54.3%
Cheviot Fringe	51,591	48,754	3,115	2,813	1,547	55.0%
Cheviots	36,488	33,786	17,966	17,847	16,439	92.1%
Chilterns	164,094	104,845	27,025	16,832	6,463	38.4%
Clun and North West Herefordshire Hills	62,552	54,350	5,850	4,712	2,839	60.2%
Cornish Killas	222,097	174,100	22,654	14,531	6,526	44.9%
Cotswolds	288,170	245,372	32,830	26,495	15,729	59.4%
Cumbria High Fells	199,007	182,230	82,668	80,627	89,227	110.7%
Dark Peak	86,605	74,425	49,411	47,217	42,094	89.1%
Dartmoor	7	79,926	44,499	43,128	39,393	91.3%
Derbyshire Peak Fringe and Lower Derwent	37,770	27,319	3,905	1,929	970	50.3%
Devon Redlands	97,404	75,089	13,104	9,950	3,272	32.9%
Dorset Downs and Cranborne Chase	116,854	104,388	18,680	15,981	6,233	39.0%
Dorset Heaths	61,662	32,509	18,752	13,746	9,402	68.4%
Dunsmore and Feldon	70,597	56,431	4,744	3,205	1,114	34.8%
Durham Coalfield Pennine Fringe	66,122	50,784	5,052	3,479	886	25.5%
Durham Magnesian Limestone Plateau	45,261	26,202	3,354	1,518	502	33.1%
East Anglian Chalk	83,870	67,926	6,480	3,955	723	18.3%
Eden Valley	80,956	72,003	5,182	4,218	1,896	45.0%
Exmoor	130,373	116,968	31,492	29,160	21,127	72.5%
Forest of Dean and Lower Wye	31,389	14,392	7,422	1,937	1,084	56.0%
Greater Thames Estuary	83,675	52,626	30,894	23,995	#N/A	#N/A
Hampshire Downs	148,912	121,087	22,637	16,719	3,987	23.8%
Hensbarrow	11,949	7,628	2,320	1,600	461	28.8%
Herefordshire Lowlands	88,680	76,513	6,442	5,219	2,367	45.4%
Herefordshire Plateau	34,635	31,311	3,236	2,739	922	33.7%
High Leicestershire	56,875	50,779	2,372	1,664	642	38.6%
High Weald	174,885	111,484	42,026	25,497	9,969	39.1%
Holderness	87,282	72,943	5,748	4,870	748	15.4%
Howardian Hills	24,011	21,064	2,367	1,856	1,099	59.2%
Howgill Fells	10,360	10,073	2,668	2,620	2,902	110.7%
Humber Estuary	27,950	16,687	3,154	2,275	784	34.5%
Humberhead Levels	171,805	136,612	22,310	15,805	2,700	17.1%
Inner London	33,012	765	2,313	485	332	68.6%
Isle of Porland	1,124	240	402	135	#N/A	#N/A
Isle of Wight	38,017	25,800	7,392	4,531	3,000	66.2%
Isles of Scilly	1,638	1,340	709	685	#N/A	#N/A
Kesteven Uplands	69,004	59,637	5,140	3,299	1,240	37.6%
Lancashire and Amounderness Plain	98,594	66,526	18,782	15,258	1,139	7.5%
Lancashire Coal Measures	40,584	17,379	3,914	1,784	457	25.6%
Lancashire Valleys	55,424	34,753	5,942	3,850	593	15.4%
Leicestershire and Nottinghamshire Wolds	64,071	53,016	3,923	2,757	1,136	41.2%
Leicestershire and South Derbyshire Coalfield	20,472	13,781	1,443	849	216	25.5%
Leicestershire Vales	71,794	48,495	2,189	1,004	281	28.0%
Lincolnshire Coast and Marshes	88,201	72,130	10,876	8,453	1,890	22.4%
Lincolnshire Wolds	84,486	78,519	5,699	5,186	2,683	51.7%
Low Weald	182,420	122,778	28,189	16,004	6,797	42.5%
Lundy	451	421	321	321	#N/A	#N/A
Malvern Hills	8,324	6,439	2,617	2,065	1,051	50.9%
Manchester Conurbation	34,223	2,439	2,759	618	#N/A	#N/A
Manchester Pennine Fringe	39,295	10,590	4,564	1,571	495	31.5%
Marshwood and Powerstock Vales	15,945	13,591	2,169	1,766	906	51.3%
Mease/Sence Lowlands	32,353	26,760	1,345	892	245	27.5%
Melbourne Parklands	15,045	11,054	1,159	803	328	40.9%
Mendip Hills	30,300	24,131	5,883	4,668	2,656	56.9%
Mersey Valley	44,718	21,105	6,536	3,911	1,446	37.0%

National Character Area	Total area (ha) of NCA	Total area (ha) of UAA within NCA	Total area (ha) of priority habitat within NCA	Total area (ha) of priority habitat within UAA within NCA	Total area (ha) of priority habitat within the UAA covered by C options	% of priority habitat covered by C options
Merseyside Conurbation	28,679	3,840	1,725	631	83	13.2%
Mid Norfolk	90,881	77,299	9,181	7,819	1,867	23.9%
Mid Northumberland	63,726	57,908	2,750	2,084	680	32.6%
Mid Severn Sandstone Plateau	88,803	56,326	10,306	5,358	2,750	51.3%
Mid Somerset Hills	42,092	34,955	7,650	6,734	1,174	17.4%
Midvale Ridge	44,501	31,694	3,850	2,497	1,107	44.3%
Morecambe Bay Limestones	39,966	32,041	16,627	13,227	4,001	30.2%
Morecambe Coast and Lune Estuary	13,211	7,854	5,680	4,354	730	16.8%
Needwood and South Derbyshire Claylands	81,540	66,660	6,183	5,011	1,599	31.9%
New Forest	73,767	52,933	38,978	33,614	25,981	77.3%
North Downs	137,447	90,040	28,316	17,593	7,452	42.4%
North East Norfolk and Flegg	24,651	19,351	1,314	816	140	17.2%
North Kent Plain	84,832	45,437	11,586	7,097	4,179	58.9%
North Norfolk Coast	6,244	5,204	4,431	3,851	1,150	29.9%
North Northumberland Coastal Plain	37,670	33,317	3,123	2,494	1,685	67.6%
North Pennines	214,563	201,096	130,293	125,746	107,179	85.2%
North West Norfolk	80,140	71,730	12,016	10,851	3,079	28.4%
North Yorkshire Moors and Cleveland Hills	165,881	131,865	59,942	53,611	47,321	88.3%
Northamptonshire Uplands	101,141	87,304	3,723	2,711	1,068	39.4%
Northamptonshire Vales	90,388	68,713	5,026	3,427	1,018	29.7%
Northern Lincolnshire Edge with Coversands	50,058	39,080	3,199	2,061	806	39.1%
Northern Thames Basin	251,000	120,979	28,017	15,407	4,330	28.1%
Northumberland Sandstone Hills	72,695	63,072	18,180	17,513	14,487	82.7%
Nottinghamshire, Derbyshire and Yorkshire Coalfield	169,753	81,058	15,599	8,124	3,656	45.0%
Orton Fells	29,281	27,810	7,038	6,922	3,329	48.1%
Oswestry Uplands	9,981	7,969	886	578	466	80.7%
Pennine Dales Fringe	87,302	74,020	6,756	5,151	1,912	37.1%
Pevensey Levels	9,638	6,097	5,285	4,760	1,652	34.7%
Potteries and Churnet Valley	53,136	31,418	5,996	3,773	1,455	38.6%
Quantock Hills	7,617	6,207	2,957	2,746	1,876	68.3%
Rockingham Forest	51,001	39,256	6,792	4,419	1,703	38.5%
Romney Marshes	36,681	30,742	9,288	7,134	3,063	42.9%
Salisbury Plain and West Wiltshire Downs	122,335	103,446	38,072	31,591	6,658	21.1%
Sefton Coast	8,989	3,898	2,933	1,775	583	32.9%
Severn and Avon Vales	210,326	160,163	28,747	23,550	6,754	28.7%
Sherwood	53,457	31,369	6,776	4,233	2,140	50.6%
Shropshire Hills	107,988	97,421	14,111	12,060	6,545	54.3%
Shropshire, Cheshire and Staffordshire Plain	366,247	290,452	21,651	14,178	5,740	40.5%
Solway Basin	98,350	84,473	22,638	19,070	5,000	26.2%
Somerset Levels and Moors	65,797	52,106	45,880	41,871	6,105	14.6%
South Coast Plain	52,245	23,163	7,375	4,751	1,328	27.9%
South Cumbria Low Fells	69,140	56,476	13,600	11,250	4,850	43.1%
South Devon	121,080	90,310	14,498	10,548	4,231	40.1%
South Downs	101,855	78,569	32,142	25,256	11,066	43.8%
South East Northumberland Coastal Plain	43,709	28,966	2,994	1,633	371	22.7%
South Hampshire Lowlands	38,634	17,126	8,544	5,169	1,754	33.9%
South Herefordshire and Over Severn	51,149	43,548	4,890	3,417	1,876	54.9%
South Norfolk and High Suffolk Claylands	214,518	186,318	13,493	10,830	2,691	24.8%
South Purbeck	11,851	10,013	2,922	2,360	2,036	86.3%
South Suffolk and North Essex Clayland	328,988	266,381	24,265	17,660	4,221	23.9%
South West Peak	42,568	37,417	10,069	9,350	5,649	60.4%
Southern Lincolnshire Edge	57,041	49,346	2,441	1,768	448	25.3%
Southern Magnesian Limestone	136,762	101,731	13,392	8,723	2,524	28.9%
Southern Pennines	119,715	91,084	36,347	32,435	25,861	79.7%
Suffolk Coast and Heaths	82,179	58,418	18,141	13,816	5,264	38.1%
Tees Lowlands	102,194	71,112	5,132	2,870	481	16.8%
Teme Valley	19,298	16,311	3,149	2,278	706	31.0%
Thames Basin Heaths	118,527	61,549	30,141	18,104	9,363	51.7%
Thames Basin Lowlands	32,783	8,733	4,539	2,914	1,672	57.4%
Thames Valley	86,062	26,250	14,193	6,575	3,885	59.1%
The Broads	56,290	44,880	23,352	20,922	8,510	40.7%
The Culm	283,072	248,301	30,141	24,205	6,574	27.2%
The Fens	382,606	336,504	25,718	21,444	5,914	27.6%
The Lizard	14,749	12,662	4,026	3,405	1,297	38.1%
Trent and Belvoir Vales	177,605	144,565	8,050	5,311	1,273	24.0%
Trent Valley Washlands	39,376	21,776	4,534	3,335	851	25.5%
Tyne and Wear Lowlands	46,418	17,225	3,552	1,724	799	46.3%
Tyne Gap and Hadrian's Wall	43,424	37,680	4,578	3,789	1,978	52.2%
Upper Thames Clay Vales	189,000	147,560	16,202	12,750	5,006	39.3%
Vale of Mowbray	60,634	53,595	2,487	1,938	156	8.1%
Vale of Pickering	43,085	37,742	8,111	7,381	444	6.0%
Vale of Taunton and Quantock Fringes	48,403	38,268	4,900	3,748	635	16.9%
Vale of York	102,083	84,781	5,706	4,396	1,715	39.0%
Wealden Greensand	145,784	85,335	35,016	21,390	9,920	46.4%
West Cumbria Coastal Plain	49,293	36,757	9,422	7,519	2,721	36.2%
West Penwith	20,201	16,931	3,858	3,255	1,550	47.6%
Weymouth Lowlands	13,251	10,140	1,740	1,403	698	49.8%

National Character Area	Total area (ha) of NCA	Total area (ha) of UAA within NCA	Total area (ha) of priority habitat within NCA	Total area (ha) of priority habitat within UAA within NCA	Total area (ha) of priority habitat within the UAA covered by C options	% of priority habitat covered by C options
White Peak	52,860	45,441	9,630	8,281	3,892	47.0%
Wirral	16,516	9,371	3,012	2,044	1,351	66.1%
Yardley-Whittlewood Ridge	33,776	27,741	4,115	2,252	597	26.5%
Yeovil Scarplands	78,579	66,372	5,872	4,816	1,391	28.9%
Yorkshire Dales	239,984	229,813	129,491	127,223	97,641	76.7%
Yorkshire Southern Pennine Fringe	58,510	25,418	6,011	2,984	1,406	47.1%
Yorkshire Wolds	111,422	103,178	7,670	6,658	2,371	35.6%
Mean	7	240	321	135	-	0.0%
Min	81,497	62,254	13,552	10,818	5,932	41.5%
Max	382,606	336,504	130,293	127,223	107,179	110.7%
Total	12,958,101	9,898,413	2,143,178	1,714,142	947,147	-

Indicator B1: Creation options will reduce fragmentation

Table E-3 Total area of selected creation options within 'top 20%' of highly fragmented sites for all priority habitats

Priority habitat	Total area (ha) of land within the UAA within each buffer	Total area (ha) of creation options within each buffer	Total area (ha) of creation options within the UAA, within each buffer	% of the UAA within each buffer covered by creation options
All priority habitats	4,320,861	8,756	8,754	0.20%

Table E-4 Total area of selected creation options within 'bottom 80%' of highly fragmented sites for all priority habitats

Priority habitat	Total area (ha) of land within the UAA within each buffer	Total area (ha) of creation options within each buffer	Total area (ha) of creation options within the UAA, within each buffer	% of the UAA within each buffer covered by creation options
All priority habitats	2,602,999	7,902	7,901	0.30%

Table E-5 Total area of selected creation options outside of highly fragmented sites for all priority habitats

Priority habitat	Total area (ha) of land within the UAA outside of buffers	Total area (ha) of creation options outside of buffers	Total area (ha) of creation options within the UAA, outside of buffers
All priority habitats	8,166,141	373,857	373,825

Table E-6 Total area of selected creation options outside of highly fragmented sites for individual priority habitats

Priority habitat	Total area (ha) of land within the UAA outside of each fragmentation area	Total area (ha) of creation options outside of each fragmentation area	Total area (ha) of creation options within the UAA, outside of each fragmentation area
BLB = Blanket bog	9,644,649	14,101	14,100
CGM = Coastal grazing marsh	9,484,247	13,158	13,157
CSD = Coastal sand dune	9,895,569	15,554	15,553
CVS = Coastal vegetated shingle	9,902,119	15,427	15,425
FGM = Floodplain grazing marsh	8,955,713	12,365	12,364
LCG = Lowland calcareous grassland	9,285,974	13,971	13,969
LDA = Lowland dry acid grassland	9,651,219	15,487	15,485
LF = Lowland fens	9,239,789	14,268	14,267
LHT = Lowland heathland	9,485,598	15,070	15,069
LMD = Lowland dry meadows	9,666,457	15,368	15,367
LMW = Lowland meadows (wet)	8,819,127	14,227	14,226
LP = Limestone pavements	9,869,233	15,560	15,558
LRB = Lowland raised bogs	9,849,364	15,375	15,373
MCS = Maritime cliff and slope	9,859,972	15,550	15,549

MDF = Mudflats	9,807,450	15,149	15,147
MHW = Mountain heath and willow scrub	9,880,973	15,621	15,619
PMG = Purple moor grass and rush pasture	9,591,877	15,343	15,341
RDB = Reedbeds	9,754,885	15,000	14,999
SLG = Saline lagoons	9,900,893	15,601	15,600
SM = Saltmarsh	9,883,778	15,533	15,532
TOR = Orchards	8,235,911	14,071	14,069
UCG = Upland calcareous grassland	9,842,153	15,587	15,586
UHM – Upland hay meadows	9,791,292	15,621	15,619
UHT = Upland heathland	9,682,468	15,258	15,256
UFF = Upland fens and flushes	9,841,687	15,595	15,593

Table E-7 Number, % of all selected creation options and total area covered by creation options within each NCA

National Character Area	Number of creation options located within each NCA	% (of all) creation options within each NCA	Area (ha) covered by creation options within each NCA
Arden	14	0.47%	82.19
Avon Vale	3	0.10%	4.26
Bedfordshire and Cambridgeshire Claylands	37	1.23%	158.63
Bedfordshire Greensand Ridge	1	0.03%	3
Berkshire and Marlborough Downs	59	1.97%	397.8
Black Mountains and Golden Valley	1	0.03%	2.7
Blackdowns	4	0.13%	9.25
Blackmoor Vale and the Vale of Wardour	6	0.20%	17.94
Bodmin Moor	0	0.00%	0
Border Moors and Forests	0	0.00%	0
Bowland Fells	3	0.10%	232.96
Bowland Fringe and Pendle Hill	0	0.00%	0
Breckland	16	0.53%	98.2
Bristol, Avon Valleys and Ridges	2	0.07%	1.95
Cannock Chase and Cank Wood	12	0.40%	24.18
Carnmenellis	0	0.00%	0
Central Lincolnshire Vale	34	1.13%	328.15
Central North Norfolk	8	0.27%	45.76
Charnwood	0	0.00%	0
Cheshire Sandstone Ridge	4	0.13%	17.34
Cheviot Fringe	34	1.13%	241.41
Cheviots	6	0.20%	751.68
Chilterns	42	1.40%	203.29
Clun and North West Herefordshire Hills	13	0.43%	48.56
Cornish Killas	22	0.73%	61.72
Cotswolds	82	2.74%	407.15
Cumbria High Fells	7	0.23%	13.01
Dark Peak	6	0.20%	511.71
Dartmoor	1	0.03%	2.63
Derbyshire Peak Fringe and Lower Derwent	2	0.07%	10.32
Devon Redlands	7	0.23%	10.07
Dorset Downs and Cranborne Chase	47	1.57%	196
Dorset Heaths	22	0.73%	148.48
Dunsmore and Feldon	20	0.67%	97.47
Durham Coalfield Pennine Fringe	10	0.33%	22.5
Durham Magnesian Limestone Plateau	2	0.07%	5.65
East Anglian Chalk	16	0.53%	58.36
Eden Valley	4	0.13%	13.1
Exmoor	18	0.60%	511.91
Forest of Dean and Lower Wye	5	0.17%	42.84
Greater Thames Estuary	82	2.74%	276.01
Greater Thames Estuary	82	2.74%	276.01
Hampshire Downs	39	1.30%	148.62
Hensbarrow	0	0.00%	0
Herefordshire Lowlands	5	0.17%	25.44
Herefordshire Plateau	3	0.10%	19.16
High Leicestershire	2	0.07%	2.05
High Weald	18	0.60%	68.96
Holderness	53	1.77%	301.91
Howardian Hills	7	0.23%	12.14
Howgill Fells	1	0.03%	1.3
Humber Estuary	5	0.17%	29.4
Humberhead Levels	61	2.03%	269.75
Inner London	0	0.00%	0
Isle of Porland	0	0.00%	0
Isle of Wight	20	0.67%	51.67
Isles of Scilly	0	0.00%	0
Kesteven Uplands	39	1.30%	190.02
Lancashire and Amounderness Plain	19	0.63%	52.21
Lancashire Coal Measures	2	0.07%	0.71
Lancashire Valleys	3	0.10%	2.24
Leicestershire and Nottinghamshire Wolds	16	0.53%	60.58
Leicestershire and South Derbyshire Coalfield	0	0.00%	0
Leicestershire Vales	13	0.43%	62.21

National Character Area	Number of creation options located within each NCA	% (of all) creation options within each NCA	Area (ha) covered by creation options within each NCA
Lincolnshire Coast and Marshes	34	1.13%	256.6
Lincolnshire Wolds	31	1.03%	134.81
Low Weald	21	0.70%	54.76
Lundy	0	0.00%	0
Malvern Hills	0	0.00%	0
Manchester Conurbation	0	0.00%	0
Manchester Pennine Fringe	0	0.00%	0
Marshwood and Powerstock Vales	1	0.03%	4.99
Mease/Sence Lowlands	7	0.23%	25.02
Melbourne Parklands	8	0.27%	31.6
Mendip Hills	2	0.07%	7.63
Mersey Valley	9	0.30%	46.32
Merseyside Conurbation	0	0.00%	0
Mid Norfolk	14	0.47%	52.99
Mid Northumberland	1	0.03%	1.7
Mid Severn Sandstone Plateau	19	0.63%	28.61
Mid Somerset Hills	17	0.57%	55.75
Midvale Ridge	11	0.37%	22.89
Morecambe Bay Limestones	52	1.73%	154.56
Morecambe Coast and Lune Estuary	5	0.17%	1.78
Needwood and South Derbyshire Claylands	7	0.23%	31.17
New Forest	4	0.13%	26.35
North Downs	73	2.43%	326.14
North East Norfolk and Flegg	0	0.00%	0
North Kent Plain	72	2.40%	308.14
North Norfolk Coast	49	1.63%	353.37
North Northumberland Coastal Plain	33	1.10%	176.42
North Pennines	11	0.37%	379.02
North West Norfolk	50	1.67%	323.35
North Yorkshire Moors and Cleveland Hills	24	0.80%	67.1
Northamptonshire Uplands	32	1.07%	156.38
Northamptonshire Vales	31	1.03%	179.74
Northern Lincolnshire Edge with Coversands	28	0.93%	185.44
Northern Thames Basin	35	1.17%	66.73
Northumberland Sandstone Hills	13	0.43%	73.41
Nottinghamshire, Derbyshire and Yorkshire Coalfield	28	0.93%	81.25
Orton Fells	0	0.00%	0
Oswestry Uplands	3	0.10%	1.44
Pennine Dales Fringe	9	0.30%	49.39
Pevensey Levels	14	0.47%	76.15
Potteries and Churnet Valley	6	0.20%	4.77
Quantock Hills	0	0.00%	0
Rockingham Forest	7	0.23%	38.15
Romney Marshes	13	0.43%	71.73
Salisbury Plain and West Wiltshire Downs	51	1.70%	340.97
Sefton Coast	2	0.07%	5.59
Severn and Avon Vales	48	1.60%	158.5
Sherwood	8	0.27%	28.19
Shropshire Hills	29	0.97%	111.42
Shropshire, Cheshire and Staffordshire Plain	73	2.43%	322.05
Solway Basin	40	1.33%	111.38
Somerset Levels and Moors	65	2.17%	275.99
South Coast Plain	44	1.47%	249.3
South Cumbria Low Fells	2	0.07%	4.14
South Devon	9	0.30%	26.59
South Downs	45	1.50%	194.36
South East Northumberland Coastal Plain	10	0.33%	73.97
South Hampshire Lowlands	6	0.20%	43.35
South Herefordshire and Over Severn	8	0.27%	42.52
South Norfolk and High Suffolk Claylands	9	0.30%	27.73
South Purbeck	9	0.30%	84.12
South Suffolk and North Essex Clayland	17	0.57%	46.29
South West Peak	6	0.20%	10.65
Southern Lincolnshire Edge	6	0.20%	36.22
Southern Magnesian Limestone	32	1.07%	95.49
Southern Pennines	2	0.07%	71.8
Suffolk Coast and Heaths	72	2.40%	207.09
Tees Lowlands	4	0.13%	16.32
Teme Valley	4	0.13%	26.78
Thames Basin Heaths	22	0.73%	82.65
Thames Basin Lowlands	0	0.00%	0
Thames Valley	4	0.13%	8.46
The Broads	58	1.93%	167.7
The Culm	38	1.27%	118.84
The Fens	231	7.71%	1314.57
The Lizard	6	0.20%	27.17
Trent and Belvoir Vales	59	1.97%	345.39
Trent Valley Washlands	38	1.27%	101.03
Tyne and Wear Lowlands	0	0.00%	0
Tyne Gap and Hadrian's Wall	0	0.00%	0
Upper Thames Clay Vales	21	0.70%	127.85
Vale of Mowbray	3	0.10%	19.57
Vale of Pickering	23	0.77%	139.41

National Character Area	Number of creation options located within each NCA	% (of all) creation options within each NCA	Area (ha) covered by creation options within each NCA
Vale of Taunton and Quantock Fringes	0	0.00%	0
Vale of York	14	0.47%	48.38
Wealden Greensand	13	0.43%	48.66
West Cumbria Coastal Plain	14	0.47%	51.1
West Penwith	3	0.10%	4.5
Weymouth Lowlands	5	0.17%	28.21
White Peak	0	0.00%	0
Wirral	3	0.10%	22.73
Yardley-Whittlewood Ridge	6	0.20%	22.31
Yeovil Scarplands	3	0.10%	8.34
Yorkshire Dales	4	0.13%	50.43
Yorkshire Southern Pennine Fringe	1	0.03%	7
Yorkshire Wolds	14	0.47%	53.3
Mean	19	0.6%	99
Min	0	0.0%	0
Max	231	7.7%	1315
Total	2,998	100%	15,897

Indicator B2: Restoration options will support the reduction of fragmentation

Table E-8 Total area of selected restoration options within 'top 20%' of high fragmented sites for all priority habitats

Priority habitat	Total area (ha) of land within the UAA within each buffer	Total area (ha) of creation and restoration options within each buffer	Total area (ha) of creation and restoration options within the UAA, within each buffer	% of the UAA within each buffer covered by creation and restoration options
All priority habitats	4,320,861	288,679	287,890	6.7%

Table E-9 Total area of selected restoration options within 'bottom 80%' of highly fragmented sites for all priority habitats

Priority habitat	Total area (ha) of land within the UAA within each buffer	Total area (ha) of creation and restoration options within each buffer	Total area (ha) of creation and restoration options within the UAA, within each buffer	% of the UAA within each buffer covered by creation and restoration options
All priority habitats	2,602,999	237,390	237,251	9.1%

Table E-10 Total area of selected core restoration options outside of highly fragmented sites for individual priority habitats

Priority habitat	Total area (ha) of land within the UAA outside of each fragmentation area	Total area (ha) of restoration options outside of each fragmentation area	Total area (ha) of restoration options within the UAA, outside of each fragmentation area
BLB = Blanket bog	9,644,649	446,732	446,921
CGM = Coastal grazing marsh	9,484,247	539,148	539,154
CSD = Coastal sand dune	9,895,569	542,181	542,181
CVS = Coastal vegetated shingle	9,902,119	542,701	542,701
FGM = Floodplain grazing marsh	8,955,713	529,249	529,258
LCG = Lowland calcareous grassland	9,285,974	513,401	513,416
LDA = Lowland dry acid grassland	9,651,219	519,765	519,810
LF = Lowland fens	9,239,789	489,879	489,922
LHT = Lowland heathland	9,485,598	469,987	470,347
LMD = Lowland dry meadows	9,666,457	535,207	535,207
LMW = Lowland meadows (wet)	8,819,127	509,133	509,152
LP = Limestone pavements	9,869,233	531,370	531,516
LRB = Lowland raised bogs	9,849,364	540,739	540,739
MCS = Maritime cliff and slope	9,859,972	539,267	539,277
MDF = Mudflats	9,807,450	541,986	541,986
MHW = Mountain heath and willow scrub	9,880,973	522,537	522,537
PMG = Purple moor grass and rush pasture	9,591,877	523,959	523,988
RDB = Reedbeds	9,754,885	538,872	538,885
SLG = Saline lagoons	9,900,893	542,919	542,919
SM = Saltmarsh	9,883,778	542,531	542,531

TOR = Orchards	8,235,911	523,773	523,730
UCG = Upland calcareous grassland	9,842,153	521,771	521,771
UHM - Upland hay meadows	9,791,292	527,293	527,336
UHT = Upland heathland	9,682,468	501,395	501,439
UFF = Upland fens and flushes	9,841,687	517,463	517,463

Indicator E1: Creation and restoration options will be focused within areas supporting the Outcome 1D objective

Table E-11 Total areas, and % of total areas, covered by different habitat potential zones within NCAs

National Character Area	Total area (ha) of NCA	Total area (ha) covered by saltmarsh habitat potential area	% of total area covered by saltmarsh habitat potential area	Total area (ha) covered by sand dune habitat potential area	% of total area covered by sand dune habitat potential area	Total area (ha) covered by vegetated shingle habitat potential area	% of total area covered by vegetated shingle habitat potential area	Total area (ha) covered by Fen habitat potential area	% of total area covered by fen habitat potential area	Total area (ha) covered by lowland raised bog habitat potential area	% of total area covered by lowland raised bog habitat potential area	Total area (ha) covered by reedbed habitat potential area	% of total area covered by reedbed habitat potential area	Total area (ha) covered by blanket bog habitat potential area	% of total area covered by blanket bog habitat potential area
Arden	143,425	0.00	0.00%	0.00	0.00%	0.00	0.00%	40,401	28.17%	0.00	0.00%	1,860	1.30%	-	0.00%
Avon Vale	64,285	0.00	0.00%	0.00	0.00%	0.00	0.00%	24,664	38.37%	0.00	0.00%	1,910	2.97%	-	0.00%
Bedfordshire and Cambridgeshire Claylands	260,560	0.00	0.00%	0.00	0.00%	0.00	0.00%	27,248	10.46%	13.38	0.01%	6,530	2.51%	-	0.00%
Bedfordshire Greensand Ridge	27,337	0.00	0.00%	0.00	0.00%	0.00	0.00%	1,612	5.90%	0.00	0.00%	246	0.90%	-	0.00%
Berkshire and Marlborough Downs	110,986	0.00	0.00%	0.00	0.00%	0.00	0.00%	4,865	4.38%	0.00	0.00%	434	0.39%	-	0.00%
Black Mountains and Golden Valley	25,974	0.00	0.00%	0.00	0.00%	0.00	0.00%	1,136	4.37%	0.00	0.00%	98	0.38%	215	0.83%
Blackdowns	80,807	0.00	0.00%	0.00	0.00%	0.00	0.00%	6,193	7.66%	0.00	0.00%	524	0.65%	829	1.03%
Blackmoor Vale and the Vale of Wardour	78,414	0.00	0.00%	0.00	0.00%	0.00	0.00%	29,487	37.60%	0.00	0.00%	2,052	2.62%	-	0.00%
Bodmin Moor	28,579	0.00	0.00%	0.00	0.00%	0.00	0.00%	205	0.72%	0.00	0.00%	-	0.00%	7,366	25.78%
Border Moors and Forests	127,156	0	0.00%	0.00	0.00%	0.00	0.00%	6,191	4.87%	3876.88	3.05%	442	0.35%	60,822	47.83%
Bowland Fells	37,395	0.00	0.00%	0.00	0.00%	0.00	0.00%	1,550	4.15%	0.00	0.00%	83	0.22%	6,658	17.80%
Bowland Fringe and Pendle Hill	74,090	0.00	0.00%	0.00	0.00%	0.00	0.00%	21,067	28.43%	0.00	0.00%	680	0.92%	7,751	10.46%
Breckland	101,926	0.00	0.00%	0.00	0.00%	0.00	0.00%	9,711	9.53%	0.00	0.00%	1,633	1.60%	-	0.00%
Bristol, Avon Valleys and Ridges	84,255	0.00	0.00%	0.00	0.00%	0.00	0.00%	15,433	18.32%	0.00	0.00%	1,059	1.26%	-	0.00%
Cannock Chase and Cank Wood	72,791	0.00	0.00%	0.00	0.00%	0.00	0.00%	11,970	16.44%	0.00	0.00%	434	0.60%	-	0.00%
Carnmenellis	14,328	0.00	0.00%	0.00	0.00%	0.00	0.00%	31	0.22%	0.00	0.00%	-	0.00%	463	3.23%
Central Lincolnshire Vale	81,898	0.00	0.00%	0.00	0.00%	0.00	0.00%	62,926	76.83%	0.00	0.00%	12,042	14.70%	-	0.00%
Central North Norfolk	72,035	0.00	0.00%	0.00	0.00%	0.00	0.00%	8,371	11.62%	0.00	0.00%	681	0.95%	-	0.00%
Charnwood	17,464	0.00	0.00%	0.00	0.00%	0.00	0.00%	3,032	17.36%	0.00	0.00%	38	0.22%	-	0.00%
Cheshire Sandstone Ridge	22,042	0.00	0.00%	0.00	0.00%	0.00	0.00%	5,190	23.54%	0.00	0.00%	123	0.56%	-	0.00%
Cheviot Fringe	51,591	0	0.00%	0.00	0.00%	0.00	0.00%	16,448	31.88%	0.00	0.00%	268	0.52%	12	0.02%
Cheviots	36,488	0	0.00%	0.00	0.00%	0.00	0.00%	265	0.73%	0.00	0.00%	2	0.01%	8,837	24.22%
Chilterns	164,094	0.00	0.00%	0.00	0.00%	0.00	0.00%	11,577	7.06%	0.00	0.00%	1,112	0.68%	-	0.00%
Clun and North West Herefordshire Hills	62,552	0.00	0.00%	0.00	0.00%	0.00	0.00%	4,554	7.28%	0.00	0.00%	1,546	2.47%	1,546	2.47%
Cornish Killas	222,097	32.38	0.01%	1014.05	0.46%	1046.43	0.47%	6,104	2.75%	0.00	0.00%	246	0.11%	2,481	1.12%
Cotswolds	288,170	0.00	0.00%	0.00	0.00%	0.00	0.00%	23,908	8.30%	0.00	0.00%	1,259	0.44%	-	0.00%
Cumbria High Fells	199,007	0.00	0.00%	0.00	0.00%	0.00	0.00%	9,686	4.87%	61.75	0.03%	623	0.31%	19,179	9.64%

National Character Area	Total area (ha) of NCA	Total area (ha) covered by saltmarsh habitat potential area	% of total area covered by saltmarsh habitat potential area	Total area (ha) covered by sand dune habitat potential area	% of total area covered by sand dune habitat potential area	Total area (ha) covered by vegetated shingle habitat potential area	% of total area covered by vegetated shingle habitat potential area	Total area (ha) covered by Fen habitat potential area	% of total area covered by fen habitat potential area	Total area (ha) covered by lowland raised bog habitat potential area	% of total area covered by lowland raised bog habitat potential area	Total area (ha) covered by reedbed habitat potential area	% of total area covered by reedbed habitat potential area	Total area (ha) covered by blanket bog habitat potential area	% of total area covered by blanket bog habitat potential area
Dark Peak	86,605	0.00	0.00%	0.00	0.00%	0.00	0.00%	2,079	2.40%	0.00	0.00%	56	0.06%	10,376	11.98%
Dartmoor	87,407	0.00	0.00%	0.00	0.00%	0.00	0.00%	479	0.55%	0.00	0.00%	3	0.00%	12,301	14.07%
Derbyshire Peak Fringe and Lower Derwent	37,770	0.00	0.00%	0.00	0.00%	0.00	0.00%	5,996	15.88%	0.00	0.00%	536	1.42%	147	0.39%
Devon Redlands	97,404	0.00	0.00%	0.00	0.00%	0.00	0.00%	8,138	8.36%	0.00	0.00%	1,210	1.24%	-	0.00%
Dorset Downs and Cranborne Chase	116,854	0.00	0.00%	0.00	0.00%	0.00	0.00%	5,737	4.91%	0.00	0.00%	905	0.77%	149	0.13%
Dorset Heaths	61,662	18.91	0.03%	10.16	0.02%	29.07	0.05%	13,756	22.31%	0.00	0.00%	1,112	1.80%	-	0.00%
Dunsmore and Feldon	70,597	0.00	0.00%	0.00	0.00%	0.00	0.00%	27,156	38.47%	0.00	0.00%	1,456	2.06%	-	0.00%
Durham Coalfield Pennine Fringe	66,122	0.00	0.00%	0.00	0.00%	0.00	0.00%	15,956	24.13%	0.00	0.00%	175	0.26%	1,017	1.54%
Durham Magnesian Limestone Plateau	45,261	0.00	0.00%	15.81	0.03%	15.81	0.03%	14,704	32.49%	0.00	0.00%	159	0.35%	-	0.00%
East Anglian Chalk	83,870	0.00	0.00%	0.00	0.00%	0.00	0.00%	10,772	12.84%	0.00	0.00%	600	0.72%	-	0.00%
Eden Valley	80,956	0.00	0.00%	0.00	0.00%	0.00	0.00%	19,713	24.35%	0.00	0.00%	955	1.18%	23	0.03%
Exmoor	130,373	0.00	0.00%	13.19	0.01%	13.19	0.01%	1,754	1.35%	0.00	0.00%	235	0.18%	7,135	5.47%
Forest of Dean and Lower Wye	31,389	0.00	0.00%	0.00	0.00%	0.00	0.00%	1,911	6.09%	0.00	0.00%	28	0.09%	-	0.00%
Greater Thames Estuary	19,593	18.86	0.10%	0.00	0.00%	18.86	0.10%	3,679	18.78%	0.00	0.00%	2,371	12.10%	-	0.00%
Greater Thames Estuary	19,593	18.86	0.10%	0.00	0.00%	18.86	0.10%	3,679	18.78%	0.00	0.00%	2,371	12.10%	-	0.00%
Hampshire Downs	148,912	0.00	0.00%	0.00	0.00%	0.00	0.00%	6,639	4.46%	0.00	0.00%	521	0.35%	-	0.00%
Hensbarrow	11,949	0.00	0.00%	0.00	0.00%	0.00	0.00%	107	0.90%	0.00	0.00%	-	0.00%	1,802	15.08%
Herefordshire Lowlands	88,680	0.00	0.00%	0.00	0.00%	0.00	0.00%	16,203	18.27%	0.00	0.00%	4,146	4.68%	-	0.00%
Herefordshire Plateau	34,635	0.00	0.00%	0.00	0.00%	0.00	0.00%	83	0.24%	0.00	0.00%	-	0.00%	-	0.00%
High Leicestershire	56,875	0.00	0.00%	0.00	0.00%	0.00	0.00%	18,172	31.95%	0.00	0.00%	661	1.16%	-	0.00%
High Weald	174,885	0.00	0.00%	0.00	0.00%	0.00	0.00%	16,657	9.52%	0.00	0.00%	2,056	1.18%	-	0.00%
Holderness	87,282	0.00	0.00%	0.00	0.00%	0.00	0.00%	53,747	61.58%	0.00	0.00%	11,607	13.30%	-	0.00%
Howardian Hills	24,011	0.00	0.00%	0.00	0.00%	0.00	0.00%	6,235	25.97%	0.00	0.00%	674	2.81%	120	0.50%
Howgill Fells	10,360	0.00	0.00%	0.00	0.00%	0.00	0.00%	144	1.39%	0.00	0.00%	21	0.20%	3,282	31.68%
Humber Estuary	27,950	51.56	0.18%	0.00	0.00%	51.56	0.18%	15,490	55.42%	0.00	0.00%	12,195	43.63%	-	0.00%
Humberhead Levels	171,805	0.00	0.00%	0.00	0.00%	0.00	0.00%	119,854	69.76%	359.38	0.21%	66,590	38.76%	-	0.00%
Inner London	33,012	0.00	0.00%	0.00	0.00%	0.00	0.00%	2,066	6.26%	0.00	0.00%	259	0.79%	-	0.00%
Isle of Porland	1,124	0.00	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	0.00	0.00%	-	0.00%	-	0.00%
Isle of Wight	38,017	0.00	0.00%	0.00	0.00%	0.00	0.00%	183	0.48%	0.00	0.00%	95	0.25%	-	0.00%
Isles of Scilly	1,638	0.00	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	0.00	0.00%	-	0.00%	-	0.00%
Kesteven Uplands	69,004	0.00	0.00%	0.00	0.00%	0.00	0.00%	23,836	34.54%	0.00	0.00%	1,092	1.58%	-	0.00%
Lancashire and Amounderness Plain	98,594	436.29	0.44%	133.88	0.14%	570.17	0.58%	52,108	52.85%	6040.25	6.13%	9,194	9.32%	-	0.00%
Lancashire Coal Measures	40,584	0.00	0.00%	0.00	0.00%	0.00	0.00%	15,887	39.15%	70.53	0.17%	295	0.73%	266	0.66%
Lancashire Valleys	55,424	0.00	0.00%	0.00	0.00%	0.00	0.00%	11,528	20.80%	0.00	0.00%	548	0.99%	3,905	7.05%

National Character Area	Total area (ha) of NCA	Total area (ha) covered by saltmarsh habitat potential area	% of total area covered by saltmarsh habitat potential area	Total area (ha) covered by sand dune habitat potential area	% of total area covered by sand dune habitat potential area	Total area (ha) covered by vegetated shingle habitat potential area	% of total area covered by vegetated shingle habitat potential area	Total area (ha) covered by Fen habitat potential area	% of total area covered by fen habitat potential area	Total area (ha) covered by lowland raised bog habitat potential area	% of total area covered by lowland raised bog habitat potential area	Total area (ha) covered by reedbed habitat potential area	% of total area covered by reedbed habitat potential area	Total area (ha) covered by blanket bog habitat potential area	% of total area covered by blanket bog habitat potential area
Leicestershire and Nottinghamshire Wolds	64,071	0.00	0.00%	0.00	0.00%	0.00	0.00%	27,693	43.22%	0.00	0.00%	950	1.48%	-	0.00%
Leicestershire and South Derbyshire Coalfield	20,472	0.00	0.00%	0.00	0.00%	0.00	0.00%	6,412	31.32%	0.00	0.00%	128	0.63%	-	0.00%
Leicestershire Vales	71,794	0.00	0.00%	0.00	0.00%	0.00	0.00%	41,040	57.16%	0.00	0.00%	1,885	2.63%	-	0.00%
Lincolnshire Coast and Marshes	88,201	19.31	0.02%	354.85	0.40%	367.10	0.42%	66,452	75.34%	0.00	0.00%	27,209	30.85%	-	0.00%
Lincolnshire Wolds	84,486	0.00	0.00%	0.00	0.00%	0.00	0.00%	14,742	17.45%	0.00	0.00%	702	0.83%	-	0.00%
Low Weald	182,420	0.00	0.00%	0.00	0.00%	0.00	0.00%	104,810	57.46%	0.00	0.00%	10,034	5.50%	-	0.00%
Lundy	451	0.00	0.00%	0.00	0.00%	0.00	0.00%	-	0.00%	0.00	0.00%	-	0.00%	-	0.00%
Malvern Hills	8,324	0.00	0.00%	0.00	0.00%	0.00	0.00%	935	11.24%	0.00	0.00%	23	0.28%	-	0.00%
Manchester Conurbation	34,223	0.00	0.00%	0.00	0.00%	0.00	0.00%	5,721	16.72%	45.93	0.13%	474	1.38%	55	0.16%
Manchester Pennine Fringe	39,295	0.00	0.00%	0.00	0.00%	0.00	0.00%	4,909	12.49%	38.43	0.10%	144	0.37%	855	2.18%
Marshwood and Powerstock Vales	15,945	0.00	0.00%	0.00	0.00%	0.00	0.00%	1,377	8.64%	0.00	0.00%	66	0.41%	-	0.00%
Mease/Sence Lowlands	32,353	0.00	0.00%	0.00	0.00%	0.00	0.00%	9,374	28.97%	0.00	0.00%	1,184	3.66%	-	0.00%
Melbourne Parklands	15,045	0.00	0.00%	0.00	0.00%	0.00	0.00%	2,151	14.30%	0.00	0.00%	179	1.19%	-	0.00%
Mendip Hills	30,300	0.00	0.00%	0.00	0.00%	0.00	0.00%	6,922	22.84%	0.00	0.00%	66	0.22%	-	0.00%
Mersey Valley	44,718	29.31	0.07%	0.00	0.00%	29.31	0.07%	19,086	42.68%	3325.24	7.44%	1,759	3.93%	-	0.00%
Merseyside Conurbation	28,679	0.00	0.00%	264.91	0.92%	264.91	0.92%	7,210	25.14%	5.78	0.02%	360	1.25%	-	0.00%
Mid Norfolk	90,881	0.00	0.00%	0.00	0.00%	0.00	0.00%	30,421	33.47%	0.00	0.00%	1,290	1.42%	-	0.00%
Mid Northumberland	63,726	0.00	0.00%	0.00	0.00%	0.00	0.00%	36,035	56.55%	0.00	0.00%	632	0.99%	190	0.30%
Mid Severn Sandstone Plateau	88,803	0.00	0.00%	0.00	0.00%	0.00	0.00%	10,853	12.22%	0.00	0.00%	243	0.27%	-	0.00%
Mid Somerset Hills	42,092	0.00	0.00%	0.00	0.00%	0.00	0.00%	4,793	11.39%	0.00	0.00%	698	1.66%	-	0.00%
Midvale Ridge	44,501	0.00	0.00%	0.00	0.00%	0.00	0.00%	16,072	36.12%	0.00	0.00%	1,347	3.03%	-	0.00%
Morecambe Bay Limestones	39,966	9.63	0.02%	0.00	0.00%	9.63	0.02%	3,177	7.95%	216.90	0.54%	264	0.66%	334	0.83%
Morecambe Coast and Lune Estuary	13,211	138.83	1.05%	23.81	0.18%	162.64	1.23%	1,312	9.93%	26.52	0.20%	539	4.08%	-	0.00%
Needwood and South Derbyshire Claylands	81,540	0.00	0.00%	0.00	0.00%	0.00	0.00%	29,102	35.69%	7.75	0.01%	2,901	3.56%	-	0.00%
New Forest	73,767	52.39	0.07%	0.00	0.00%	52.39	0.07%	12,536	16.99%	0.00	0.00%	596	0.81%	-	0.00%
North Downs	137,447	0.00	0.00%	0.00	0.00%	0.00	0.00%	3,510	2.55%	0.00	0.00%	393	0.29%	-	0.00%
North East Norfolk and Flegg	24,651	0.00	0.00%	97.80	0.40%	97.80	0.40%	2,375	9.63%	0.00	0.00%	216	0.88%	-	0.00%
North Kent Plain	84,832	10.13	0.01%	159.56	0.19%	169.70	0.20%	14,057	16.57%	0.00	0.00%	4,433	5.23%	-	0.00%
North Norfolk Coast	6,244	51.03	0.82%	4.25	0.07%	55.28	0.89%	956	15.31%	0.00	0.00%	446	7.14%	-	0.00%
North Northumberland Coastal Plain	37,670	0	0.00%	358.77	0.95%	358.77	0.95%	14,553	38.63%	0	0.00%	920	2.44%	-	0.00%
North Pennines	214,563	0.00	0.00%	0.00	0.00%	0.00	0.00%	6,444	3.00%	433.00	0.20%	121	0.06%	28,617	13.34%

National Character Area	Total area (ha) of NCA	Total area (ha) covered by saltmarsh habitat potential area	% of total area covered by saltmarsh habitat potential area	Total area (ha) covered by sand dune habitat potential area	% of total area covered by sand dune habitat potential area	Total area (ha) covered by vegetated shingle habitat potential area	% of total area covered by vegetated shingle habitat potential area	Total area (ha) covered by Fen habitat potential area	% of total area covered by fen habitat potential area	Total area (ha) covered by lowland raised bog habitat potential area	% of total area covered by lowland raised bog habitat potential area	Total area (ha) covered by reedbed habitat potential area	% of total area covered by reedbed habitat potential area	Total area (ha) covered by blanket bog habitat potential area	% of total area covered by blanket bog habitat potential area
North West Norfolk	80,140	22.01	0.03%	0.00	0.00%	22.01	0.03%	12,285	15.33%	0.00	0.00%	2,296	2.87%	-	0.00%
North Yorkshire Moors and Cleveland Hills	165,881	0.00	0.00%	0.00	0.00%	0.00	0.00%	13,312	8.03%	0.00	0.00%	290	0.17%	11,109	6.70%
Northamptonshire Uplands	101,141	0.00	0.00%	0.00	0.00%	0.00	0.00%	48,059	47.52%	0.00	0.00%	2,301	2.28%	-	0.00%
Northamptonshire Vales	90,388	0.00	0.00%	0.00	0.00%	0.00	0.00%	23,852	26.39%	0.00	0.00%	3,278	3.63%	-	0.00%
Northern Lincolnshire Edge with Coversands	50,058	0.00	0.00%	0.00	0.00%	0.00	0.00%	13,502	26.97%	0.00	0.00%	2,190	4.37%	-	0.00%
Northern Thames Basin	251,000	8.12	0.00%	0.00	0.00%	8.12	0.00%	77,169	30.74%	0.00	0.00%	5,034	2.01%	-	0.00%
Northumberland Sandstone Hills	72,695	0	0.00%	0.00	0.00%	0.00	0.00%	12,841	17.66%	715.44	0.98%	255	0.35%	12,726	17.51%
Nottinghamshire, Derbyshire and Yorkshire Coalfield	169,753	0.00	0.00%	0.00	0.00%	0.00	0.00%	33,405	19.68%	0.00	0.00%	1,728	1.02%	83	0.05%
Orton Fells	29,281	0.00	0.00%	0.00	0.00%	0.00	0.00%	5,880	20.08%	0.00	0.00%	186	0.64%	1,533	5.24%
Oswestry Uplands	9,981	0.00	0.00%	0.00	0.00%	0.00	0.00%	1,487	14.90%	0.00	0.00%	14	0.14%	161	1.61%
Pennine Dales Fringe	87,302	0.00	0.00%	0.00	0.00%	0.00	0.00%	23,299	26.69%	0.00	0.00%	398	0.46%	4,327	4.96%
Pevensey Levels	9,638	0.00	0.00%	145.05	1.50%	145.05	1.50%	1,004	10.42%	0.00	0.00%	191	1.98%	-	0.00%
Potteries and Churnet Valley	53,136	0.00	0.00%	0.00	0.00%	0.00	0.00%	8,859	16.67%	0.00	0.00%	425	0.80%	706	1.33%
Quantock Hills	7,617	0.00	0.00%	0.00	0.00%	0.00	0.00%	11	0.14%	0.00	0.00%	1	0.01%	-	0.00%
Rockingham Forest	51,001	0.00	0.00%	0.00	0.00%	0.00	0.00%	8,194	16.07%	0.00	0.00%	199	0.39%	-	0.00%
Romney Marshes	36,681	0.00	0.00%	633.99	1.73%	633.99	1.73%	21,290	58.04%	0.00	0.00%	16,541	45.09%	-	0.00%
Salisbury Plain and West Wiltshire Downs	122,335	0.00	0.00%	0.00	0.00%	0.00	0.00%	3,689	3.02%	0.00	0.00%	811	0.66%	-	0.00%
Sefton Coast	8,989	0.00	0.00%	251.78	2.80%	251.78	2.80%	2,683	29.85%	373.52	4.16%	551	6.13%	-	0.00%
Severn and Avon Vales	210,326	58.91	0.03%	0.00	0.00%	58.91	0.03%	39,433	18.75%	0.00	0.00%	8,064	3.83%	-	0.00%
Sherwood	53,457	0.00	0.00%	0.00	0.00%	0.00	0.00%	3,695	6.91%	0.00	0.00%	619	1.16%	-	0.00%
Shropshire Hills	107,988	0.00	0.00%	0.00	0.00%	0.00	0.00%	17,564	16.26%	0.00	0.00%	850	0.79%	1,316	1.22%
Shropshire, Cheshire and Staffordshire Plain	366,247	0.00	0.00%	0.00	0.00%	0.00	0.00%	185,779	50.73%	0.00	0.00%	8,149	2.22%	102	0.03%
Solway Basin	98,350	30.00	0.03%	91.56	0.09%	121.56	0.12%	40,495	41.17%	1032.12	1.05%	2,095	2.13%	312	0.32%
Somerset Levels and Moors	65,797	11.94	0.02%	66.09	0.10%	78.03	0.12%	4,904	7.45%	518.31	0.79%	2,553	3.88%	-	0.00%
South Coast Plain	52,245	0.00	0.00%	164.15	0.31%	164.15	0.31%	14,249	27.27%	0.00	0.00%	2,042	3.91%	-	0.00%
South Cumbria Low Fells	69,140	0.00	0.00%	0.00	0.00%	0.00	0.00%	1,158	1.68%	28.06	0.04%	52	0.08%	4,513	6.53%
South Devon	121,080	0.00	0.00%	0.00	0.00%	0.00	0.00%	5,249	4.34%	0.00	0.00%	105	0.09%	314	0.26%
South Downs	101,855	0.00	0.00%	6.87	0.01%	6.87	0.01%	3,035	2.98%	0.00	0.00%	298	0.29%	-	0.00%
South East Northumberland Coastal Plain	43,709	0.00	0.00%	216.99	0.50%	216.99	0.50%	23,706	54.23%	0.00	0.00%	618	1.41%	-	0.00%
South Hampshire Lowlands	38,634	0.00	0.00%	0.00	0.00%	0.00	0.00%	11,154	28.87%	0.00	0.00%	503	1.30%	-	0.00%
South Herefordshire and Over Severn	51,149	0.00	0.00%	0.00	0.00%	0.00	0.00%	2,306	4.51%	0.00	0.00%	99	0.19%	-	0.00%

National Character Area	Total area (ha) of NCA	Total area (ha) covered by saltmarsh habitat potential area	% of total area covered by saltmarsh habitat potential area	Total area (ha) covered by sand dune habitat potential area	% of total area covered by sand dune habitat potential area	Total area (ha) covered by vegetated shingle habitat potential area	% of total area covered by vegetated shingle habitat potential area	Total area (ha) covered by Fen habitat potential area	% of total area covered by fen habitat potential area	Total area (ha) covered by lowland raised bog habitat potential area	% of total area covered by lowland raised bog habitat potential area	Total area (ha) covered by reedbed habitat potential area	% of total area covered by reedbed habitat potential area	Total area (ha) covered by blanket bog habitat potential area	% of total area covered by blanket bog habitat potential area
South Norfolk and High Suffolk Claylands	214,518	0.00	0.00%	0.00	0.00%	0.00	0.00%	122,827	57.26%	0.00	0.00%	1,985	0.93%	-	0.00%
South Purbeck	11,851	0.00	0.00%	0.00	0.00%	0.00	0.00%	735	6.21%	0.00	0.00%	15	0.12%	-	0.00%
South Suffolk and North Essex Clayland	328,988	0.00	0.00%	0.00	0.00%	0.00	0.00%	32,363	9.84%	0.00	0.00%	1,757	0.53%	-	0.00%
South West Peak	42,568	0.00	0.00%	0.00	0.00%	0.00	0.00%	2,495	5.86%	0.00	0.00%	53	0.12%	10,088	23.70%
Southern Lincolnshire Edge	57,041	0.00	0.00%	0.00	0.00%	0.00	0.00%	17,702	31.03%	0.00	0.00%	1,551	2.72%	-	0.00%
Southern Magnesian Limestone	136,762	0.00	0.00%	0.00	0.00%	0.00	0.00%	28,045	20.51%	0.00	0.00%	2,154	1.58%	-	0.00%
Southern Pennines	119,715	0.00	0.00%	0.00	0.00%	0.00	0.00%	4,321	3.61%	0.00	0.00%	390	0.33%	33,092	27.64%
Suffolk Coast and Heaths	82,179	69.81	0.08%	184.48	0.22%	254.29	0.31%	10,410	12.67%	0.00	0.00%	2,659	3.24%	-	0.00%
Tees Lowlands	102,194	0.00	0.00%	53.32	0.05%	53.32	0.05%	60,699	59.40%	0.00	0.00%	2,196	2.15%	-	0.00%
Teme Valley	19,298	0.00	0.00%	0.00	0.00%	0.00	0.00%	1,360	7.05%	0.00	0.00%	-	0.00%	-	0.00%
Thames Basin Heaths	118,527	0.00	0.00%	0.00	0.00%	0.00	0.00%	37,677	31.79%	0.00	0.00%	3,306	2.79%	-	0.00%
Thames Basin Lowlands	32,783	0.00	0.00%	0.00	0.00%	0.00	0.00%	8,894	27.13%	0.00	0.00%	708	2.16%	-	0.00%
Thames Valley	86,062	0.00	0.00%	0.00	0.00%	0.00	0.00%	26,448	30.73%	0.00	0.00%	2,902	3.37%	-	0.00%
The Broads	56,290	42.59	0.08%	13.58	0.02%	56.17	0.10%	12,379	21.99%	0.00	0.00%	7,933	14.09%	-	0.00%
The Culm	283,072	0.00	0.00%	17.69	0.01%	17.69	0.01%	34,105	12.05%	0.00	0.00%	1,320	0.47%	2,524	0.89%
The Fens	382,606	166.08	0.04%	95.54	0.02%	261.63	0.07%	323,691	84.60%	923.68	0.24%	261,677	68.39%	-	0.00%
The Lizard	14,749	0.00	0.00%	9.69	0.07%	9.69	0.07%	3,948	26.77%	0.00	0.00%	0	0.00%	-	0.00%
Trent and Belvoir Vales	177,605	0.00	0.00%	0.00	0.00%	0.00	0.00%	88,835	50.02%	0.00	0.00%	24,781	13.95%	-	0.00%
Trent Valley Washlands	39,376	0.00	0.00%	0.00	0.00%	0.00	0.00%	17,877	45.40%	0.00	0.00%	5,669	14.40%	-	0.00%
Tyne and Wear Lowlands	46,418	0.00	0.00%	9.43	0.02%	9.43	0.02%	12,956	27.91%	0.00	0.00%	170	0.37%	-	0.00%
Tyne Gap and Hadrian's Wall	43,424	0.00	0.00%	0.00	0.00%	0.00	0.00%	9,096	20.95%	87.88	0.20%	77	0.18%	1,758	4.05%
Upper Thames Clay Vales	189,000	0.00	0.00%	0.00	0.00%	0.00	0.00%	96,998	51.32%	0.00	0.00%	16,190	8.57%	-	0.00%
Vale of Mowbray	60,634	0.00	0.00%	0.00	0.00%	0.00	0.00%	33,627	55.46%	0.00	0.00%	2,050	3.38%	-	0.00%
Vale of Pickering	43,085	0.00	0.00%	0.00	0.00%	0.00	0.00%	19,573	45.43%	0.00	0.00%	5,495	12.75%	-	0.00%
Vale of Taunton and Quantock Fringes	48,403	0.00	0.00%	0.00	0.00%	0.00	0.00%	2,870	5.93%	0.00	0.00%	650	1.34%	-	0.00%
Vale of York	102,083	0.00	0.00%	0.00	0.00%	0.00	0.00%	65,139	63.81%	0.00	0.00%	8,094	7.93%	-	0.00%
Wealden Greensand	145,784	0.00	0.00%	105.07	0.07%	105.07	0.07%	24,536	16.83%	0.00	0.00%	1,112	0.76%	-	0.00%
West Cumbria Coastal Plain	49,293	0.00	0.00%	172.75	0.35%	172.75	0.35%	9,601	19.48%	10.27	0.02%	267	0.54%	344	0.70%
West Penwith	20,201	0.00	0.00%	49.25	0.24%	49.25	0.24%	44	0.22%	0.00	0.00%	-	0.00%	1,419	7.02%
Weymouth Lowlands	13,251	75.19	0.57%	29.59	0.22%	104.78	0.79%	1,757	13.26%	0.00	0.00%	151	1.14%	-	0.00%
White Peak	52,860	0.00	0.00%	0.00	0.00%	0.00	0.00%	11,958	22.62%	0.00	0.00%	112	0.21%	3,012	5.70%
Wirral	16,516	64.13	0.39%	184.27	1.12%	248.40	1.50%	6,505	39.38%	0.00	0.00%	268	1.63%	-	0.00%
Yardley-Whittlewood Ridge	33,776	0.00	0.00%	0.00	0.00%	0.00	0.00%	9,100	26.94%	0.00	0.00%	268	0.79%	-	0.00%
Yeovil Scarplands	78,579	0.00	0.00%	0.00	0.00%	0.00	0.00%	9,520	12.12%	0.00	0.00%	1,064	1.35%	95	0.12%
Yorkshire Dales	239,984	0.00	0.00%	0.00	0.00%	0.00	0.00%	7,274	3.03%	0.00	0.00%	710	0.30%	68,104	28.38%

National Character Area	Total area (ha) of NCA	Total area (ha) covered by saltmarsh habitat potential area	% of total area covered by saltmarsh habitat potential area	Total area (ha) covered by sand dune habitat potential area	% of total area covered by sand dune habitat potential area	Total area (ha) covered by vegetated shingle habitat potential area	% of total area covered by vegetated shingle habitat potential area	Total area (ha) covered by Fen habitat potential area	% of total area covered by fen habitat potential area	Total area (ha) covered by lowland raised bog habitat potential area	% of total area covered by lowland raised bog habitat potential area	Total area (ha) covered by reedbed habitat potential area	% of total area covered by reedbed habitat potential area	Total area (ha) covered by blanket bog habitat potential area	% of total area covered by blanket bog habitat potential area
Yorkshire Southern Pennine Fringe	58,510	0.00	0.00%	0.00	0.00%	0.00	0.00%	3,324	5.68%	0.00	0.00%	172	0.29%	2,518	4.30%
Yorkshire Wolds	111,422	0.00	0.00%	0.00	0.00%	0.00	0.00%	10,361	9.30%	0.00	0.00%	189	0.17%	-	0.00%

Indicator F1: Creation options around existing semi-natural areas will create larger conservation sites

Table E-12 Total number and total areas of selected creation options within 100 m, <0.5 km, <1 km and >1 km of existing priority habitat

National Character Area	Number of creation options located within each NCA	Total area (ha) covered by creation options within NCA	Number of creation options located within 100m of existing habitat within NCA	Total area (ha) covered by creation options within 100m of existing habitat within NCA	Number of creation options located within 0.5km of existing habitat within NCA	Total area (ha) covered by creation options within 0.5km of existing habitat within NCA	Number of creation options located within 1km of existing habitat within NCA	Total area (ha) covered by creation options within 1km of existing habitat within NCA	Number of creation options located within >1km of existing habitat within NCA	Total area (ha) covered by creation options in areas >1km of existing habitat within NCA
Arden	16	32.2	17	34.7	19	35.8	28	38.7	5,529	15,911
Avon Vale	7	4.8	8	5.3	11	12.5	13	15.5	5,544	15,934
Bedfordshire and Cambridgeshire Claylands	85	70.2	85	70.2	94	83.0	101	110.4	5,456	15,839
Bedfordshire Greensand Ridge	7	20.4	7	20.4	9	21.5	9	21.5	5,548	15,928
Berkshire and Marlborough Downs	85	429.7	86	438.0	90	445.1	91	448.1	5,466	15,501
Black Mountains and Golden Valley	17	13.1	17	13.1	17	13.1	17	13.1	5,540	15,936
Blackdowns	44	96.4	44	96.4	45	98.0	50	110.5	5,507	15,839
Blackmoor Vale and the Vale of Wardour	10	20.4	15	32.9	23	64.5	34	90.9	5,523	15,859
Bodmin Moor	0	-	0	-	0	-	0	-	5,557	15,950
Border Moors and Forests	52	61.8	52	61.8	56	64.9	58	87.9	5,499	15,862
Bowland Fells	35	279.8	35	279.8	37	281.1	42	283.5	5,515	15,666
Bowland Fringe and Pendle Hill	36	16.8	37	17.1	43	18.5	45	19.2	5,512	15,930
Breckland	22	79.2	24	86.2	27	96.1	31	110.9	5,526	15,839
Bristol, Avon Valleys and Ridges	38	25.4	38	25.4	39	25.9	42	28.7	5,515	15,921
Cannock Chase and Cank Wood	14	24.8	21	31.9	22	36.4	23	36.5	5,534	15,913
Carnmenellis	0	-	0	-	0	-	0	-	5,557	15,950
Central Lincolnshire Vale	24	64.7	25	64.5	26	70.6	27	72.3	5,530	15,877
Central North Norfolk	25	51.9	24	51.8	31	84.3	34	127.5	5,523	15,822
Charnwood	2	0.7	2	0.7	2	0.7	2	0.7	5,555	15,949
Cheshire Sandstone Ridge	4	13.3	4	13.3	6	20.3	9	21.1	5,548	15,929
Cheviot Fringe	33	42.9	35	44.4	40	83.3	42	84.8	5,515	15,865
Cheviots	8	752.0	9	753.0	9	753.0	12	754.2	5,545	15,195
Chilterns	52	207.4	52	207.4	52	207.4	55	209.0	5,502	15,741
Clun and North West Herefordshire Hills	79	45.6	79	45.6	79	45.6	83	56.4	5,474	15,893
Cornish Killas	30	51.5	30	51.5	31	52.2	31	52.2	5,526	15,897
Cotswolds	141	440.8	145	447.0	153	463.6	159	469.7	5,398	15,480
Cumbria High Fells	432	2,363.7	436	2,479.7	443	2,491.4	451	2,498.5	5,106	13,451
Dark Peak	32	621.1	32	621.1	36	630.8	37	632.5	5,520	15,317
Dartmoor	23	12.4	23	12.4	24	13.3	25	13.8	5,532	15,936
Derbyshire Peak Fringe and Lower Derwent	11	25.8	11	25.8	13	39.5	13	39.5	5,544	15,910
Devon Redlands	29	20.5	29	20.5	31	22.4	35	26.3	5,522	15,923
Dorset Downs and Cranborne Chase	54	200.7	54	205.1	59	222.3	64	243.3	5,493	15,706
Dorset Heaths	21	118.8	22	119.0	22	119.0	23	120.5	5,534	15,829
Dunsmore and Feldon	19	51.8	19	51.8	22	60.7	23	66.3	5,534	15,883

National Character Area	Number of creation options located within each NCA	Total area (ha) covered by creation options within NCA	Number of creation options located within 100m of existing habitat within NCA	Total area (ha) covered by creation options within 100m of existing habitat within NCA	Number of creation options located within 0.5km of existing habitat within NCA	Total area (ha) covered by creation options within 0.5km of existing habitat within NCA	Number of creation options located within 1km of existing habitat within NCA	Total area (ha) covered by creation options within 1km of existing habitat within NCA	Number of creation options located within >1km of existing habitat within NCA	Total area (ha) covered by creation options in areas >1km of existing habitat within NCA
Durham Coalfield Pennine Fringe	1	2.0	1	2.0	2	3.2	4	3.8	5,553	15,946
Durham Magnesian Limestone Plateau	0	-	0	-	0	-	0	-	5,557	15,950
East Anglian Chalk	36	61.0	36	61.0	40	64.7	41	65.7	5,516	15,884
Eden Valley	44	34.7	46	35.0	60	41.6	80	96.5	5,477	15,853
Exmoor	40	506.7	40	506.7	41	507.1	43	513.1	5,514	15,436
Forest of Dean and Lower Wye	17	22.5	17	22.5	17	22.5	19	28.2	5,538	15,921
Greater Thames Estuary	75	127.9	81	133.9	82	148.0	83	148.8	5,474	15,801
Greater Thames Estuary	75	127.9	81	133.9	82	148.0	83	148.8	5,474	15,801
Hampshire Downs	49	139.9	49	139.9	52	166.5	53	171.7	5,504	15,778
Hensbarrow	0	-	0	-	0	-	0	-	5,557	15,950
Herefordshire Lowlands	28	23.0	28	23.0	38	34.3	43	45.0	5,514	15,905
Herefordshire Plateau	28	41.9	28	41.9	29	42.3	35	48.8	5,522	15,901
High Leicestershire	17	8.9	17	8.9	18	9.9	20	14.0	5,537	15,936
High Weald	20	61.2	22	65.4	28	83.5	33	96.4	5,524	15,853
Holderness	39	175.9	39	175.9	39	175.9	39	175.9	5,518	15,774
Howardian Hills	10	5.6	11	6.4	11	6.4	12	12.2	5,545	15,937
Howgill Fells	28	382.8	29	383.1	37	385.1	41	386.5	5,516	15,563
Humber Estuary	0	-	0	-	0	-	0	-	5,557	15,950
Humberhead Levels	30	42.8	31	43.2	31	43.2	33	47.6	5,524	15,902
Inner London	1	0.9	2	1.2	3	1.3	3	1.3	5,554	15,948
Isle of Porland	0	-	0	-	0	-	0	-	5,557	15,950
Isle of Wight	46	77.3	46	77.3	46	77.3	46	77.3	5,511	15,872
Isles of Scilly	0	-	0	-	0	-	0	-	5,557	15,950
Kesteven Uplands	51	235.3	51	235.3	56	268.4	61	325.4	5,496	15,624
Lancashire and Amounderness Plain	23	41.6	26	43.9	29	45.1	31	45.5	5,526	15,904
Lancashire Coal Measures	3	1.3	3	1.3	3	1.3	3	1.3	5,554	15,948
Lancashire Valleys	11	6.2	11	6.2	15	8.0	15	8.0	5,542	15,942
Leicestershire and Nottinghamshire Wolds	23	38.4	25	49.5	31	59.9	36	70.0	5,521	15,880
Leicestershire and South Derbyshire Coalfield	13	37.6	14	43.3	14	43.3	19	61.7	5,538	15,888
Leicestershire Vales	7	16.2	7	16.2	7	16.2	8	17.2	5,549	15,932
Lincolnshire Coast and Marshes	8	13.3	7	12.7	9	14.8	10	19.5	5,547	15,930
Lincolnshire Wolds	44	106.0	46	111.5	47	118.4	50	118.8	5,507	15,831
Low Weald	48	111.9	49	113.0	52	114.6	54	117.9	5,503	15,832
Lundy	0	-	0	-	0	-	0	-	5,557	15,950
Malvern Hills	9	4.6	9	4.6	11	5.7	14	7.4	5,543	15,942
Manchester Conurbation	0	-	0	-	0	-	0	-	5,557	15,950
Manchester Pennine Fringe	0	-	0	-	0	-	0	-	5,557	15,950
Marshwood and Powerstock Vales	6	9.7	6	9.7	8	10.9	8	10.9	5,549	15,939
Mease/Sence Lowlands	0	-	0	-	1	0.4	1	0.4	5,556	15,949

National Character Area	Number of creation options located within each NCA	Total area (ha) covered by creation options within NCA	Number of creation options located within 100m of existing habitat within NCA	Total area (ha) covered by creation options within 100m of existing habitat within NCA	Number of creation options located within 0.5km of existing habitat within NCA	Total area (ha) covered by creation options within 0.5km of existing habitat within NCA	Number of creation options located within 1km of existing habitat within NCA	Total area (ha) covered by creation options within 1km of existing habitat within NCA	Number of creation options located within >1km of existing habitat within NCA	Total area (ha) covered by creation options in areas >1km of existing habitat within NCA
Melbourne Parklands	14	47.6	16	53.2	25	74.5	27	85.2	5,530	15,864
Mendip Hills	8	11.2	8	11.2	9	12.4	11	19.7	5,546	15,930
Mersey Valley	6	27.2	6	27.2	6	27.2	6	27.2	5,551	15,922
Merseyside Conurbation	1	0.5	2	2.3	2	2.3	4	10.4	5,553	15,939
Mid Norfolk	66	103.8	66	103.8	67	104.1	70	106.3	5,487	15,843
Mid Northumberland	13	12.0	13	12.0	14	12.5	18	17.2	5,539	15,932
Mid Severn Sandstone Plateau	40	34.6	49	37.9	52	39.1	54	50.8	5,503	15,899
Mid Somerset Hills	24	59.2	24	59.2	30	83.5	42	117.6	5,515	15,832
Midvale Ridge	12	23.1	12	23.1	12	23.1	12	23.1	5,545	15,926
Morecambe Bay Limestones	66	160.7	66	160.7	67	160.8	68	164.8	5,489	15,785
Morecambe Coast and Lune Estuary	8	2.8	9	2.8	9	2.8	10	2.9	5,547	15,947
Needwood and South Derbyshire Claylands	30	88.0	30	88.0	32	88.5	33	89.5	5,524	15,860
New Forest	26	46.4	26	46.4	26	46.4	26	46.4	5,531	15,903
North Downs	75	317.7	76	319.4	76	319.4	81	323.5	5,476	15,626
North East Norfolk and Flegg	0	-	0	-	7	11.8	23	49.5	5,534	15,900
North Kent Plain	14	26.7	14	26.7	16	28.1	16	28.1	5,541	15,922
North Norfolk Coast	13	84.7	14	90.7	16	97.3	18	105.1	5,539	15,844
North Northumberland Coastal Plain	16	38.0	17	39.8	21	44.2	24	52.4	5,533	15,897
North Pennines	260	979.6	262	982.0	270	989.4	277	995.2	5,280	14,954
North West Norfolk	49	207.0	51	213.2	58	238.1	67	251.4	5,490	15,698
North Yorkshire Moors and Cleveland Hills	77	122.4	77	122.4	77	122.4	77	122.4	5,480	15,827
Northamptonshire Uplands	78	173.2	79	175.5	82	176.1	85	177.6	5,472	15,772
Northamptonshire Vales	52	148.0	53	148.3	59	166.9	66	168.6	5,491	15,781
Northern Lincolnshire Edge with Coversands	16	43.8	16	43.8	16	43.8	16	43.8	5,541	15,906
Northern Thames Basin	66	79.6	71	83.9	84	113.1	109	153.8	5,448	15,796
Northumberland Sandstone Hills	48	104.7	50	113.3	63	122.8	69	126.3	5,488	15,823
Nottinghamshire, Derbyshire and Yorkshire Coalfield	37	55.2	37	55.2	37	55.2	41	63.7	5,516	15,886
Orton Fells	82	84.7	84	85.8	89	95.0	97	98.2	5,460	15,851
Oswestry Uplands	12	5.5	12	5.5	12	5.5	12	5.5	5,545	15,944
Pennine Dales Fringe	20	18.4	20	18.4	21	21.4	23	22.6	5,534	15,927
Pevensey Levels	7	21.2	7	21.2	7	21.2	7	21.2	5,550	15,928
Potteries and Churnet Valley	21	9.0	22	9.8	22	9.8	24	13.3	5,533	15,936
Quantock Hills	2	1.0	2	1.0	2	1.0	2	1.0	5,555	15,949
Rockingham Forest	28	144.2	28	144.2	32	157.1	33	158.0	5,524	15,792
Romney Marshes	7	21.3	8	25.2	8	25.2	8	25.2	5,549	15,924
Salisbury Plain and West Wiltshire Downs	66	345.7	66	345.7	69	352.3	69	352.3	5,488	15,597
Sefton Coast	0	-	1	0.5	1	0.5	2	2.3	5,555	15,947

National Character Area	Number of creation options located within each NCA	Total area (ha) covered by creation options within NCA	Number of creation options located within 100m of existing habitat within NCA	Total area (ha) covered by creation options within 100m of existing habitat within NCA	Number of creation options located within 0.5km of existing habitat within NCA	Total area (ha) covered by creation options within 0.5km of existing habitat within NCA	Number of creation options located within 1km of existing habitat within NCA	Total area (ha) covered by creation options within 1km of existing habitat within NCA	Number of creation options located within >1km of existing habitat within NCA	Total area (ha) covered by creation options in areas >1km of existing habitat within NCA
Severn and Avon Vales	118	160.1	120	160.8	124	162.9	135	173.1	5,422	15,776
Sherwood	23	16.2	23	16.2	23	16.2	23	16.2	5,534	15,933
Shropshire Hills	105	75.1	105	75.1	110	76.6	112	77.0	5,445	15,873
Shropshire, Cheshire and Staffordshire Plain	99	209.7	100	209.8	101	210.2	103	211.1	5,454	15,739
Solway Basin	66	100.3	66	100.3	66	100.3	68	101.3	5,489	15,848
Somerset Levels and Moors	47	170.0	47	170.0	50	171.2	51	174.4	5,506	15,775
South Coast Plain	39	207.3	39	207.3	43	213.5	43	213.5	5,514	15,736
South Cumbria Low Fells	53	41.1	54	41.8	62	171.9	79	199.4	5,478	15,750
South Devon	43	49.9	43	49.9	43	49.9	44	50.4	5,513	15,899
South Downs	26	176.1	26	176.1	28	186.3	30	188.4	5,527	15,761
South East Northumberland Coastal Plain	3	3.1	3	3.1	3	3.1	5	3.4	5,552	15,946
South Hampshire Lowlands	8	32.5	8	32.5	8	32.5	8	32.5	5,549	15,917
South Herefordshire and Over Severn	54	58.5	55	59.0	55	59.0	59	61.9	5,498	15,888
South Norfolk and High Suffolk Claylands	80	64.7	84	71.1	87	72.5	95	76.0	5,462	15,874
South Purbeck	13	104.1	13	104.1	20	161.0	24	181.3	5,533	15,768
South Suffolk and North Essex Clayland	92	112.6	92	112.6	95	114.3	97	123.0	5,460	15,827
South West Peak	22	18.3	23	18.5	24	19.4	25	19.6	5,532	15,930
Southern Lincolnshire Edge	13	45.1	13	45.1	14	47.5	14	47.5	5,543	15,902
Southern Magnesian Limestone	43	75.7	43	75.7	50	89.0	57	107.0	5,500	15,843
Southern Pennines	50	120.7	50	120.7	50	120.7	51	120.9	5,506	15,829
Suffolk Coast and Heaths	72	149.4	72	149.4	74	150.6	77	151.2	5,480	15,798
Tees Lowlands	3	2.5	3	2.5	3	2.5	3	2.5	5,554	15,947
Teme Valley	15	10.8	15	10.8	16	12.2	17	12.7	5,540	15,937
Thames Basin Heaths	48	104.3	48	104.3	48	104.3	49	109.2	5,508	15,840
Thames Basin Lowlands	1	0.9	1	0.9	1	0.9	1	0.9	5,556	15,949
Thames Valley	14	16.9	14	16.9	14	16.9	14	16.9	5,543	15,933
The Broads	52	103.9	52	103.9	54	105.7	60	122.9	5,497	15,827
The Culm	111	152.6	112	152.7	114	154.0	115	159.7	5,442	15,790
The Fens	83	274.1	85	279.6	90	290.2	97	308.6	5,460	15,641
The Lizard	14	28.6	14	28.6	14	28.6	14	28.6	5,543	15,921
Trent and Belvoir Vales	46	114.2	50	132.1	58	149.7	59	150.7	5,498	15,799
Trent Valley Washlands	11	6.3	11	6.3	12	8.1	15	9.4	5,542	15,940
Tyne and Wear Lowlands	1	0.3	1	0.3	1	0.3	1	0.3	5,556	15,949
Tyne Gap and Hadrian's Wall	14	9.3	14	9.3	14	9.3	18	12.0	5,539	15,938
Upper Thames Clay Vales	24	53.3	25	56.7	29	73.2	31	86.7	5,526	15,863
Vale of Mowbray	4	3.5	4	3.5	5	3.9	5	3.9	5,552	15,946
Vale of Pickering	9	15.3	9	15.3	12	17.6	14	33.7	5,543	15,916
Vale of Taunton and Quantock Fringes	8	5.4	10	17.2	12	17.8	24	55.8	5,533	15,894

National Character Area	Number of creation options located within each NCA	Total area (ha) covered by creation options within NCA	Number of creation options located within 100m of existing habitat within NCA	Total area (ha) covered by creation options within 100m of existing habitat within NCA	Number of creation options located within 0.5km of existing habitat within NCA	Total area (ha) covered by creation options within 0.5km of existing habitat within NCA	Number of creation options located within 1km of existing habitat within NCA	Total area (ha) covered by creation options within 1km of existing habitat within NCA	Number of creation options located within >1km of existing habitat within NCA	Total area (ha) covered by creation options in areas >1km of existing habitat within NCA
Vale of York	14	26.8	14	26.8	15	27.4	16	29.3	5,541	15,920
Wealden Greensand	26	68.3	26	68.3	30	85.0	37	115.6	5,520	15,834
West Cumbria Coastal Plain	52	64.3	52	64.4	58	66.8	75	80.1	5,482	15,870
West Penwith	1	0.6	1	0.6	1	0.6	1	0.6	5,556	15,949
Weymouth Lowlands	6	33.3	6	33.3	6	33.3	6	33.3	5,551	15,916
White Peak	5	5.0	5	5.0	8	6.5	15	27.8	5,542	15,922
Wirral	3	8.7	3	8.7	3	8.7	3	8.7	5,554	15,941
Yardley-Whittlewood Ridge	26	29.1	27	31.4	29	32.3	33	46.3	5,524	15,903
Yeovil Scarplands	17	25.7	17	25.7	21	46.9	23	55.1	5,534	15,895
Yorkshire Dales	173	358.0	173	358.0	179	361.8	183	394.7	5,374	15,555
Yorkshire Southern Pennine Fringe	14	10.0	14	10.0	14	10.0	15	10.3	5,542	15,939
Yorkshire Wolds	22	55.0	22	55.0	25	68.4	27	69.3	5,530	15,880

Appendix F. Outputs from Workshop 1

This section documents the outputs from Workshop 1, held at Nobel House, London, on Monday 7th September, 2015. Alongside the Steering Group, a number of additional experts attended, comprising:

Table F-1 Workshop 1 attendees

Name	Organisation
Humphrey Crick	Natural England
Ian Crosher	Natural England
Tim Collins	Natural England
Iain Diack	Natural England
Isobel Alonso	Natural England
Emma Goldberg	Natural England
Mark Broadmeadow	Forestry Commission
Steve Peel	Natural England
Mike Green	Natural England
Lindsey Stewart	Natural England
David Heaver	Natural England
Andy Cooke	Natural England
Jeff Edwards	Natural England
Harold Makant	Natural England
Serena Leadley	Natural England

Outputs from the workshop are provided in the A3 pull-outs overleaf.

Different adaptation strategies and their applicability at a range of different scales (outputs from Group 1)

National	Catchment	Farm
2. Develop contingency plans		- Flood impacts - Slurry volumes - Moving cattle & feed → grazing
3. Monitoring of climate change impacts		
5. Reduce other pressures on biodiversity		
6. Support appropriate management of designated sites and priority habitats		
7. Identify and support through management existing hotspots for species Identify hotspots for adaptation action	Identify hotspots for adaptation action	Manage hotspots for CC adaptation
19. Reduce risk of soil erosion		
21. Adjusting objectives/targets to take account of changing species distributions e.g. recognising new or potential colonists		
32. Tree planting to manage run-off and flood risk		
24. Translocation or facilitating dispersal of species to newly suitable habitats		
33. Think big – habitat creation on a large scale		Planning policy → CC adaptation
34. Move from spaces to communities/assemblages (designation approach)		
35. Produce a set of National Adaptation Indicators		
36. Review the flexibility of designations to accept change		
17. Promote the potential for natural genetic exchange between populations		
23. Adjusting boundaries of sites to account for inevitable change e.g. through managed realignment		
	4. Enabling an adaptive management approach i.e. adjustment of plans in light of changing circumstances	Better coordination of adaptation response between neighbouring land managers
	14. Maintain or increase habitat heterogeneity at landscape scale	
	20. Reduce risk of wildfire	
	28. Restore wetlands (or functioning floodplains) to promote flood storage capacity	
	30. Peat restoration to promote water storage	
	31. Coastal habitat restoration to reduce the risk of coastal flooding	
	1. Incorporating climate change adaptation into management plans	
	8. Increase the size of semi-natural habitat patches	
	9. Provide buffer areas around semi-natural habitat	
	10. Improve the functional connectivity between semi-natural habitat patches	
	12. Protect ∕ create cool microclimates and potential refugia for species Landscape climate refugia	Micro climate refugia
	15. Maintain species diversity within communities	
	16. Protect or restore hydrological function	
	18. Control invasive species	
	26. Promote riparian shading	
	29. Restore wetland to reduce pollution/filter water	
	39. Increase temporal heterogeneity	
		13. Maintain or increase the habitat heterogeneity at site scale
		22. Adjusting timings of operations such as grazing, hay cutting and hedge cutting to take account of changing phenology
		27. Plant trees and manage hedgerow to provide shading for livestock
11. Protect/create habitats most sensitive to climate change		11. Protect/create habitats most sensitive to climate change
25. Increase the flexibility of management systems		25. Increase the flexibility of management systems

Note: Adaptation principles (left column): Planning for climate change adaptation; Build resilience; Preparing for and accommodating inevitable change; Identify opportunities for ecosystem-based adaptation. Additional strategies in coral.

Different adaptation strategies and their applicability at a range of different scales (outputs from Group 2)

<table>
<tr><th>National</th><th>Catchment</th><th>Farm</th></tr>
<tr><td colspan="3">2. Develop contingency plans
Depends on hazard or government agency</td></tr>
<tr><td colspan="3">3. Monitoring of climate change impacts
Difference between monitoring and reporting. Different types of monitoring e.g. site-based samples vs. remote sensing. Website on experiences at farm level of weather</td></tr>
<tr><td colspan="3">5. Reduce other pressures on biodiversity</td></tr>
<tr><td colspan="3">15. Maintain species diversity within communities
Communities as assemblage of species</td></tr>
<tr><td colspan="3">18. Control invasive species</td></tr>
<tr><td colspan="3">21. Adjusting objectives/targets to take account of changing species distributions e.g. recognising new or potential colonists
National research implemented at site. Catchment/landscape also relevant</td></tr>
<tr><td colspan="3">24. Translocation or facilitating dispersal of species to newly suitable habitats
Connection to landscape? Probably need support at this scale e.g. permeability. Includes plants e.g. Forestry French providence</td></tr>
<tr><td></td><td>13. Maintain or increase the habitat heterogeneity at site scale</td><td></td></tr>
<tr><td></td><td>28. Restore wetlands (or functioning floodplains) to promote flood storage capacity</td><td></td></tr>
<tr><td></td><td>29. Restore wetland to reduce pollution/filter water</td><td></td></tr>
<tr><td></td><td>30. Peat restoration to promote water storage</td><td></td></tr>
<tr><td></td><td>31. Coastal habitat restoration to reduce the risk of coastal flooding</td><td></td></tr>
<tr><td></td><td>32. Tree planting to manage run-off and flood risk
Tree management at local level to avoid local problems</td><td></td></tr>
<tr><td></td><td>36. Habitat creation for flood risk and water quality management and water retention</td><td></td></tr>
<tr><td></td><td>37. Soil management to manage run-off and flood risk</td><td></td></tr>
<tr><td></td><td colspan="2">1. Incorporating climate change adaptation into management plans</td></tr>
<tr><td></td><td colspan="2">6. Support appropriate management of designated sites and priority habitats
What's allowed, so link to national</td></tr>
<tr><td></td><td colspan="2">9. Provide buffer areas around semi-natural habitat</td></tr>
<tr><td></td><td colspan="2">10. Improve the functional connectivity between semi-natural habitat patches</td></tr>
<tr><td></td><td colspan="2">16. Protect or restore hydrological function
Catchment but also site level relevance e.g. wetlands, ponds, SUDS</td></tr>
<tr><td></td><td colspan="2">17. Promote the potential for natural genetic exchange between populations</td></tr>
<tr><td></td><td colspan="2">19. Reduce risk of soil erosion</td></tr>
<tr><td></td><td colspan="2">20. Reduce risk of wildfire
Cannot find through national stewardship without live risk map</td></tr>
<tr><td></td><td colspan="2">23. Adjusting boundaries of sites to account for inevitable change e.g. through managed realignment
Takes wider view e.g. looking along coast</td></tr>
<tr><td></td><td colspan="2">26. Promote riparian shading</td></tr>
<tr><td></td><td colspan="2">35. Maintain and increase/provide resources for sustaining pollinator population and that this is adapted to a changing climate</td></tr>
<tr><td></td><td></td><td>8. Increase the size of semi-natural habitat patches
E.g. derogation – PRA rules etc. inc. legislation that constrain. Could possibly be farm/national</td></tr>
<tr><td></td><td></td><td>12. Protect ⁄ create cool microclimates and potential refugia for species
Two different measures: Spatial targeting (identity areas) within a site – local level management</td></tr>
<tr><td></td><td></td><td>14. Maintain or increase habitat heterogeneity at landscape scale</td></tr>
<tr><td></td><td></td><td>22. Adjusting timings of operations such as grazing, hay cutting and hedge cutting to take account of changing phenology</td></tr>
<tr><td></td><td></td><td>27. Plant trees and manage hedgerow to provide shading for livestock</td></tr>
<tr><td></td><td></td><td>33. Creation of on-farm reservoirs</td></tr>
<tr><td></td><td></td><td>34. Promoting natural regenerations in woodlands i.e. trimming, continuous cover</td></tr>
<tr><td>4. Enabling an adaptive management approach i.e. adjustment of plans in light of changing circumstances</td><td></td><td>4. Enabling an adaptive management approach i.e. adjustment of plans in light of changing circumstances</td></tr>
<tr><td>7. Identify and support through managing existing hotspots for species</td><td></td><td>7. Identify and support through managing existing hotspots for species</td></tr>
<tr><td>11. Protect/create habitats most sensitive to climate change</td><td></td><td>11. Protect/create habitats most sensitive to climate change</td></tr>
<tr><td>25. Increase the flexibility of management systems</td><td></td><td>25. Increase the flexibility of management systems</td></tr>
</table>

How does/could agri-environment management contribute to these adaptation strategies at a local (case study square) scale?

- To what extent do the agri-environment measures currently employed in the square contribute to adaptation?
- How (if at all) does this vary spatially within the case study square?
- What else could be done through agri-environment schemes to contribute to adaptation (if at all)?
- Create a list of recommendations for improving adaptation in the square through agri-environment schemes

Group A

10km grid:	**SK00**
Description:	This grid is located in the midlands. The town of Aldridge is located approximately 11 miles east of Wolverhampton and 12 miles north of Birmingham. The grid comprises a mixture of Grade 2 and 3 agricultural land with a significant urban landscape. It contains a small selection of priority habitats, including purple moor grass and rush pastures and deciduous woodland. The majority of the land cover is arable and horticulture and built up areas and gardens.
National Character Area(s):	Cannock Chase Cank Wood
Habitat fragmentation:	High
Species refugia:	High

Summary of discussion:

(i) To what extent do the agri-environment measures currently employed in the square contribute to adaptation?
- The square is dominated by other (non-climate change related) pressures including those from people and development (there is a significant urban presence *c.* 40% of the grid square) - Around 7% of the grid (~700ha) is under AE management; could we do more? Where are there opportunities to work with land managers to increase the land area under AE management? - General comment – using the top and bottom 33% of cells (by value) to identify areas of high and low refugia may be problematic. Perhaps we need to use a greater resolution (i.e. top/bottom 10%); it's not likely that you would prioritise actions based on such a broad range - We need to be able to understand whether it's worth it i.e. is the quality of the existing habitat at present good enough to start planning at a strategic level? Are our goals realistic? Might we be doing everything we can at the moment? - Ponds (i.e. those outside AE management) have been used in the past (not in this square) for fire contingency planning; mapping the location of available waterbodies can help to increase resilience
(ii) How (if at all) does this vary spatially within the case study square?
- There is a distinct east to west split with the majority of the agri-environment schemes options located in the west (dominated by semi-natural habitats in the east). With this in mind, the adaptation strategies applied within each location may need to be different. Indeed, the different types of agri-environment schemes options evident in the east (all ELS and predominantly linear options) and west (predominantly higher quality options, including a mixture of HLS/ELS+HLS) support this approach. - The higher quality agri-environment schemes options (i.e. HLS/ELS+HLS) seem to be located on the higher quality agricultural land - This square, and others of similar characteristics, may be limited in the level of agri-environment management due to being on the urban fringe - There are not many agri-environment schemes options in the flood zone - It's important to realise the issue of scale and locality – there are interactions at the edges of the grid with adjacent squares. This goes for working at the farm (and catchment) scales too – we need to think more effectively about the landscape as a whole and as one functioning system. Focussing ourselves is helpful but it's also absolutely necessary to look beyond, and the interactions across, multiple spatial scales

- Related to the above, more information should be provided about the relative importance of the other (surrounding) grid squares - Having some more information may help enable us to make informed decisions e.g. could we look at the present location of designated areas (and other data in general, including local wildlife sites which may be providing stepping stones to increase habitat connectivity and thereby improving resilience)?
(iii) What else could be done through agri-environment schemes to contribute to adaptation (if at all)?
-We need to understand (perhaps by mapping?) the competing pressures within the landscape in order to be able to understand where agri-environment schemes management might be able to contribute to climate change adaptation -There appears to be little opportunity for habitat creation due to the location (i.e. highly urban landscape) and other pressures (i.e. from people and development) -That being said, where should we choose to target habitat creation? -We could take a more strategic look at the interconnectivity of habitat patches (e.g. there is a central patch of woodland under an EWGS that may be providing a key area of refugia) and plan on this basis. -Furthermore, there is plenty of heathland, could we look to target options within these areas to improve connectivity and improve resilience? -There is an further pressure from invasive species but further information would be required to enable informed decisions -Reducing fragmentation is essential to improving resilience but there are often limiting factors i.e. in this case we may be limited by space (i.e. no available, or very little, habitat due to urbanisation and habitat squeeze). We could look to buffer existing habitats and improve the quality (i.e. structure and diversity) first and foremost – perhaps focussing on creating hedgerows and buffer strips around marginal habitats to improve the structure and diversity would be a good place to start (i.e. make the most of what we've got) -Land ownership issues pose a further difficulty, both in terms of future planning/forecasting and also in from increasing housing pressures (also likely in this grid given the dominance of urban areas)
(iv) Create a list of recommendations for improving adaptation in the square through agri-environment schemes
<u>Specific:</u> - Opportunities for green infrastructure (i.e. in this context – to improve urban cooling potential and increase biodiversity opportunities) - Diversify existing habitats to improve connectivity e.g. heathland in urban areas (to reduce fire risks), some areas of woodland seem not to be covered by an existing EWGS - Identify gaps in land management, specifically around issues of AE management uptake (where are the opportunities?) - Given the competing pressures in this landscape (including the lack of space) target linear agri-environment schemes options i.e. hedgerows to provide compensatory and/or additional habitat and target field margins to help reduce habitat fragmentation <u>General:</u> - Use flood zones to target areas for habitat creation to slow down the movement of water through the landscapes - Create connectivity of habitats through increasing the amount of fen/reedbeds - Understand the interrelationship (and interconnectivity) of the grid with adjacent grids, particular with regard to habitat fragmentation - Expand/buffer areas of core biodiversity - Fine resolution data is required to make decisions and to understand species change over time. Establish a more meaningful baseline beyond the traditional approach of amalgamating datasets that we currently use (i.e. land cover, land grade or priority habitats where changing definitions have been used) - Focus on, and prepare for, accommodating change as opposed to resilience (i.e. focus on heterogeneity) - Adaptive management of the landscapes, including across multiple spatial scales - Leave (align) measuring resilience to existing monitoring as it already closely aligns with existing prioritisation; focus monitoring of the contribution of AE management to climate change on accommodating change and adaptive management - Could use a combination of national-level analysis (reported by region, NCA and/or 10km x 10km grid square) supported by local monitoring to help identify elements of adaptive management - Measuring the relative success of AE management is difficult without targets to compare against. A set of metrics are required to provide a useful baseline for this purpose to aid future monitoring. There are national targets but some local targets would help to prioritise and assess success (or

not). Also, how do we measure ‘success’? Could this be related to the hypotheses (and resulting questions) that we’ve already developed? i.e. the amount of habitat creation - Related to this, adaptive management is better in NELMS but how do we measure ‘better’ in this sense? - There needs to be a recommendation on the temporal nature of monitoring; temporal heterogeneity in additional to spatial heterogeneity (i.e. timing of within and between year events)

10km grid:	**NY63**
Description:	This grid is located in the north west. The town of Melmerby is located approximately nine miles north-east of Penrith. The grid comprises predominantly Grade 5 agricultural land and it contains a small selection of priority habitats, including upland heathland and Grass Moorlands. The majority of the land cover is montane habitats, improved grassland and acid grassland.
National Character Area(s):	Eden Valley North Pennines
Habitat fragmentation:	Low
Species refugia:	High

Summary of discussion:

(i) To what extent do the agri-environment measures currently employed in the square contribute to adaptation?
- There are substantially more agri-environment schemes options within this grid square and a broader mix of habitat types. Around 16,000 ha under agri-environmental management (note: multiple options often cover the same areas, hence exceeding the total grid area) - Moorland areas (dominant habitat) are already under agri-environmental management (approximately 50% of grid square) - Predominantly ELS+HLS options
(ii) How (if at all) does this vary spatially within the case study square?
- There is a distinct east to west split with the east being highly fragmented and the west considerably less so. The vast majority of agri-environment schemes options are concentrated in the west on higher grade agricultural land whilst there are a handful of agri-environment schemes options in the east on grade 5 agricultural land. This example helps to emphasise the importance of scale – is the 10km x 10km grid scale appropriate for understanding the complexities of the problem and potential opportunities? Possibly use a different spatial unit i.e. one based ecologically based compared with the 10km x 10km grid squares? - A lot of agri-environment schemes options in close proximity to rivers and river corridors providing an opportunity to create habitat and also to increase connectivity of woodland patches - Having some more information may help enable us to make informed decisions e.g. could we look at the present location of designated areas (and other data in general, including local wildlife sites which may be providing stepping stones to increase habitat connectivity and thereby improving resilience)?
(iii) What else could be done through agri-environment schemes to contribute to adaptation (if at all)?
- Support existing habitats and/or create/improve habitat structure in upland areas - Vary use of supplements, support shepparding and grazing - Increase the heterogeneity of upland management and habitats (e.g. HLS options compared with ELS options); more tailored prescriptions including a greater range of available options - Improve quality of lowland raised bogs as these areas overlay peat which are useful stores for CO_2 - Buffer the core areas of habitat and enhance the quality, diversity and structure of surrounding habitat - Encourage the adoption of a greater range of agri-environment schemes options to improve heterogeneity of the landscape and reduce habitat fragmentation

- Focus on wetland restoration – Ecosystem-based Adaptation of adjacent areas of improved grassland - Manage the flow of water through the landscape through the use of woodland corridors around woodlands – also useful for reducing diffuse pollution - Measuring the relative success of AE management is difficult without targets to compare against. A set of metrics are required to provide a useful baseline for this purpose to aid future monitoring. There are national targets but some local targets would help to prioritise and assess success (or not). Also, how do we measure 'success'? Could this be related to the hypotheses (and resulting questions) that we've already developed? - Related to this, adaptive management is better in NELMS but how do we measure 'better' in this sense? - There needs to be a recommendation on the temporal nature of monitoring; temporal heterogeneity in additional to spatial heterogeneity (i.e. timing of within and between year events)
(iv) Create a list of recommendations for improving adaptation in the square through agri-environment schemes
Specific: -Target areas of more woodland in (or close to) areas of lowland raised bog (multiple wins, including reduced fragmentation and managed water flow through landscapes i.e. reduce diffuse pollution) - Improve water quality in downstream areas by increasing areas of scrub and woodland creation - Provide a range of agri-environment schemes option/prescriptions within options - Align habitat creation with areas of high species diversity General: - Use flood zones to target areas for habitat creation to slow down the movement of water through the landscapes - Create connectivity of habitats through increasing the amount of fen/reedbeds - Understand the interrelationship (and interconnectivity) of the grid with adjacent grids, particular with regard to habitat fragmentation - Expand/buffer areas of core biodiversity - Fine resolution data is required to make decisions and to understand species change over time. Establish a more meaningful baseline beyond the traditional approach of amalgamating datasets that we currently use (i.e. land cover, land grade or priority habitats where changing definitions have been used) - Focus on, and prepare for, accommodating change as opposed to resilience (i.e. focus on heterogeneity) - Adaptive management of the landscapes, including across multiple spatial scales - Leave (align) measuring resilience to existing monitoring as it already closely aligns with existing prioritisation; focus monitoring of the contribution of AE management to climate change on accommodating change and adaptive management - Could use a combination of national-level analysis (reported by region, NCA and/or 10km x 10km grid square) supported by local monitoring to help identify elements of adaptive management - Measuring the relative success of AE management is difficult without targets to compare against. A set of metrics are required to provide a useful baseline for this purpose to aid future monitoring. There are national targets but some local targets would help to prioritise and assess success (or not). Also, how do we measure 'success'? Could this be related to the hypotheses (and resulting questions) that we've already developed? i.e. the amount of habitat creation - Related to this, adaptive management is better in NELMS but how do we measure 'better' in this sense? - There needs to be a recommendation on the temporal nature of monitoring; temporal heterogeneity in additional to spatial heterogeneity (i.e. timing of within and between year events)

Group B

10km grid:	**SD30**
Description:	This grid is located in the north west. The town of Maghull is located approximately nine miles north-east of Liverpool. The grid comprises predominantly Grade 1 and 2 agriculture land and it contains a small selection of priority habitats, including coastal and floodplain grazing marsh and deciduous woodland. The majority of the land cover is arable and horticulture.

National Character Area(s):	Lancashire and Amounderness Plain Sefton Coast Merseyside Conurbation
Habitat fragmentation:	High
Species refugia:	Low

Summary of discussion:

(i) To what extent do the agri-environment measures currently employed in the square contribute to adaptation?
- Limited e.g. there are buffer strips providing habitat for threatened bird species but this is not an area of high biodiversity, nor an area of focus (i.e. for agri-environment schemes or conservation)
(ii) How (if at all) does this vary spatially within the case study square?
- As AE is limited there is little variation beyond that described
(iii)What else could be done through agri-environment schemes to contribute to adaptation (if at all)?
- Could focus on 'wet' areas i.e. riparian strips - Protect areas of peat from being reverted to arable (do we know how much peat is remaining?) - Habitat extension focussed on remnant areas of lowland raised bog - Consider what is already being done elsewhere i.e. in adjacent squares - Plant more hedgerows and trees to act as wind breaks and to provide riparian shading
(iv)Create a list of recommendations for improving adaptation in the square through agri-environment schemes
Specific: -This area is not likely to be a priority General (see also (iii): **-** Need national level policy in place to help manage local level conflicts e.g. land use and trade-offs between different priorities - There appear to options or packages of options on land that are supporting unsustainable agriculture; not taking the environment into account (e.g. use of peat soils for agriculture) - Assuming high grade agricultural land is used for growing food is not synonymous with best adaptation indicators. Also, agricultural grades might change under climate change rendering them meaningless (or less meaningful) - Provide greater local flexibility partly due to the quality of existing datasets (particular the resolution) - Integration of with other mechanisms / agricultural plan for the area - Ecosystem restoration i.e. thinking at scale - Linking water/catchment objectives i.e. incremental gains vs. more radical/wholesale approaches

10km grid:	**ST44**
Description:	This grid is located in the south west. The town of Wedmore is located approximately 16 miles south-east of Weston-Super-Mare. The grid comprises a mixture of Grade 2, 3 and 4 agricultural land. The grid is predominantly coastal floodplain and grazing marsh priority habitats. Other priority habitats include lowland raised bog and lowland fens. The majority of the land cover is improved grassland.
National Character Area(s):	Mid Somerset Hills Mendip Hills Somerset Levels and Moors
Habitat fragmentation:	Low
Species refugia:	Low

Summary of discussion:

(i) To what extent do the agri-environment measures currently employed in the square contribute to adaptation?
- Water retention - Habitat restoration - Potential to expand habitat - Historic environment - Could do more on refugia (i.e. maintaining wetting) - Potential for coastal/tidal (i.e. reversion of land drainage (and flood defences) to tidal/coastal flooding/habitats - Generally, agri-environment schemes options broadly reducing vulnerability
(ii) How (if at all) does this vary spatially within the case study square?
- High spatial variability visible on map
(iii) What else could be done through agri-environment schemes to contribute to adaptation (if at all)?
- Take into account catchment-based evidence, including upstream measures - More consideration of the aquatic environment (it's difficult to tell what's currently being done i.e. generic names/descriptions used for agri-environment schemes options meant that it was difficult to discern what specifically was being done on the ground without expert knowledge - Review hydrological system e.g. flow pathways - Restoration of habitats (what is the long term strategy?) - Fen creation (focus effort on central band of coastal and floodplain grazing marsh) - Woodland creation - Review new targeting measures (i.e. rye grass – improved natural grassland in new scheme)
(iv) Create a list of recommendations for improving adaptation in the square through agri-environment schemes
Specific: -See (iii) above General: - Compare ESA baseline vs. pre-ESA - Improve biodiversity across area - Improve quality of semi-natural habitat on peat - Focus on peat specifically - Restoring functional ecosystems - Better linking agri-environment schemes options with other Rural Development Programme for England (RDPE) options/schemes - Catchment/landscape-scale thinking i.e. there is potential for a facilitated group of farmers. Barrier – patchwork / number of landowners

Appendix G. Outputs from Workshop 2

This section documents the outputs from Workshop 2, held at Nobel House, London, on Friday 13th November, 2015. Alongside the Steering Group, a number of additional experts attended, comprising:

Table G-1 Workshop 2 attendees

Name	Organisation
Humphrey Crick	Natural England
Ian Crosher	Natural England
Emma Goldberg	Natural England
Andy Cooke	Natural England
James Phillips	Natural England
Helen Taylor	Environment Agency
Neil Riddle	Forestry Commission
Graham Weaver	Natural England
Isabel Alonso	Natural England
David Heaver	Natural England
Jeff Edwards	Natural England
Mike Render	Forestry Commission
Andy Neale	Natural England
Philippa Mansfield	Natural England
Bridget Leyden	Natural England

A proforma was utilised to provide structure to the group discussions, to identify key information (i.e. what data do we need? How do we collect the information that we need? How (and where) should we monitor change?) and to capture comments and/or concerns regarding the approach(es) identified. Participants were asked to discuss what the monitoring requirements might be using the hypothesis and national-scale question; the process was undertaken at both the catchment and farm-scales.

The blank pro forma appeared as follows (see below) and was populated in the group discussions. The groups were switched during the afternoon session to give the attendees an opportunity to comment on the other four adaptation indicators.

		Catchment scale				
National scale hypothesis	**National scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
1. Agri-environment options will support SSSIs and other priority habitats	What is the proportion of Priority habitat covered by Maintenance and Restoration options? What is the proportion and total area of AES options within SSSIs?					

In the tables that follow:

1. Black text is used to capture discussion from each group;
2. Blue text is used to capture comments whilst;
3. Red text captures questions;
4. Purple text captures any notes; and
5. Yellow highlights capture comments that were unintelligible.

Workshop 2 completed proformas

1. Agri-environment options will support SSSIs and other priority habitats

		Catchment scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Agri-environment options will support SSSIs and other priority habitats -Should we redefine options based on spatial scale or quality? i.e. at margins, including options located outside of habitats	What is the proportion of Priority habitat covered by Maintenance and Restoration options? What is the proportion and total area of agri-environment schemes options within SSSIs?	-Monitor the increase/decrease of priority habitat (i.e. a repeat of the same analysis undertaken at the national-scale) -Do we know how much and where we want to create habitat? (i.e. enlarging/buffering SSSIs) -Monitoring condition and extent of habitats -Climate change may exacerbate the impacts of run-off etc. from catchments on SSSIs; adaptation should therefore reduce off-site impacts -We could adopt the same monitoring questions that are applied at the national-scale to the catchment scale -Amount of habitat increasing/decreasing at catchment scale -Could use other spatial unit i.e. NCA -Identify priority species for schemes	-Already planning to report against this -CSFF facilitated fund – there is evidence at the landscape scale -WFD catchment partnerships and project teams -Nature Improvement Areas – there is a monitoring framework already in place and these are already well defined -CSF data/monitoring at the catchment scale -Non-SSSIs for habitat assessment/ monitoring -Species indicators/monitoring for climate change (speak with Gavin Measures) -Diffuse water pollution plans for N2K sites	-SSSI condition assessments do not capture adaptation (or not) to climate change -Link to Major Land Managers Group (MLMG)		-How is 'favourable' status defined and captured? The data often tells a different story to what is happening on the ground -Natural England has records of SSSI units' condition -Condition assessment criteria will have to change as the climate does -High quality water priority areas are important on sensitive habitats up/downstream, take account of flow pathways. There is a GIS dataset for upstream CSF options [HT] (see Steve Chaplin) -Comparatively, there is less habitat under management in CS

		Farm-scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the farm-scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Agri-environment options will support SSSIs and other priority habitats	What is the proportion of Priority habitat covered by Maintenance and Restoration options? What is the proportion and total area of agri-environment scheme options within SSSIs?	-Are important habitats picked up in -…and are the priority species requirements factored into the agreement? -We could adopt the same monitoring questions that are applied at the national-scale to the farm-scale	-Location (and size of) high quality habitats from the Priority Habitat Inventory (PHI) database -Farm Environment Plan (FEP), particularly focussing on high quality habitats/options (i.e. HLS) -BEHTA (focussing on Higher Tier) -Non-Priority Habitat Inventory (PHI) habitats	-Woodland management plans are compulsory for Countryside Stewardship; they include a monitoring requirement	-5-10 years -At the start/end of individual agreements	-Is there management to protect priority habitats outside of priority habitats (i.e. buffering existing habitats)?

2. Agri-environment options will reduce habitat fragmentation

		Catchment scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Agri-environment options will reduce habitat fragmentation -This seems to be more appropriate/useful at the landscape/national-scale (there seems to be a farm-scale focus)	What is the proportion and total area of appropriate creation, restoration and maintenance options in each fragmentation band? -Consider looking at mean patch size and an index of 'edginess'. See Oliver *et al.*, (2015) on drought and butterflies	-Connectivity of water -For species, what resources do the fragmented parcels deliver and how far apart are they? -How effective are Countryside Stewardship facilitation projects? Nature Improvement Areas? Catchment Sensitive Farming? -Areas in agreement vs. areas out of agreement?	-Water level management plans -Is targeting data appropriate (connections)?	-As farm-scale -Woodland habitat networks and Forestry Commission data		-How do you measure change? (land cover? Scheme monitoring? GENREP)?

		Farm-scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the farm-scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Agri-environment options will reduce habitat fragmentation	What is the proportion and total area of appropriate creation, restoration and maintenance options in each fragmentation band?	-This question should validate the national level assessment	-Mapping of habitats at the farm-scale e.g. trees/hedgerows -Identification (and mapping) of local-scale habitat networks	-Farm Environment Plans (FEP) -Farm Environment Plans data is not very good and habitat fragmentation is not captured. Countryside Stewardship will have better data as baseline for agreements. -FEPs are more useful to gather information on field-scale habitats/matrix data than Basic Payment Scheme. Basic Payment Schemes are useful however for identifying land available for creation of habitat. -FEPs are much more useful than the other datasets listed here -Resurveying of existing field surveys -Basic Payment Scheme -GENREP -Land use surveys -Woodland Management Plans may help to identify opportunities to reduce habitat fragmentation		-The Basic Payment Scheme captures changes of land that is in/out of agreement – these land parcels might represent opportunities for creating habitat

3. Restoration and maintenance options will support highly sensitive habitats

		Catchment scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Restoration and maintenance options will support highly sensitive habitats	What is the proportion of each habitat sensitivity class under creation, restoration and maintenance options?	-Are highly sensitive habitats impacted by/in appropriate options implemented elsewhere (e.g. upstream)? -Can we check this for Fen habitats?	-Keeping Rivers Cool options -Need to take into account sensitivity of the catchment and habitat quality, including species	-Modelling Catchment Sensitive Farming options used for water quality monitoring -Woodland ecological site classification tool -Change of status		-Coverage by other strategies and/or plans e.g. Water Level Management Plan -Do options support these plans (e.g. Water Level Management Plans, Shoreline Management Plans)?

		Farm-scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the farm-scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Restoration and maintenance options will support highly sensitive habitats -Is just using restoration and maintenance options appropriate at the local scale?	What is the proportion of each habitat sensitivity class under creation, restoration and maintenance options?	-Are highly sensitive habitats covered by appropriate restoration and maintenance (i.e. create for coast e.g. salt marsh) options? -Does the site management produce conditions that reduce sensitivity (e.g. increased heterogeneity)? -Define 'appropriate' -List for HLS are being developed under Countryside Stewardship [JE] -How can we assess sensitivity at the 200m (national dataset) level?	-Keeping Rivers Cool -Need to take into account local sensitivity (further work and/or guidance is needed to define this) and habitat/species quality	-Aftercare site visits? This could be difficult for non-designated sites -Change of status for designated sites -Environmental Stewardship/ Countryside Stewardship monitoring at the farm-scale samples (effectiveness)	-At least once in a 5 year agreement	-Need to check that not just the options are in place but how effective are they?

4. Restoration and creation of more sensitive habitats will be focussed on refugia

		Catchment scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Restoration and creation of more sensitive habitats will be focussed on refugia	~~What is the proportion and total area of appropriate creation, restoration and maintenance options in each fragmentation band?~~					-Neither group seems to have captured species (despite mentioning this at the beginning). It seems that the "matrix" options would [sic] be so much more important for species

		Farm-scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the farm-scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Restoration and creation of more sensitive habitats will be focussed on refugia	~~What is the proportion and total area of appropriate creation, restoration and maintenance options in each fragmentation band?~~	-Does the option support/focus on the specific habitat that supports refugia? -Are the detailed management requirements of the species using refugia adequately captured option prescriptions etc.? Is there flexibility?	-Which species to focus on? e.g. Red List (rare but not rarest) -Indicator species e.g. Biodiversity Indicators for Defra (check these)	-Existing identification of sites of rare species and bespoke management (not currently climate specific) -Selected sample monitoring?	-5 years to fit with the agreement cycle	-When agreement end, undertake a review of effectiveness

5. Agri-environment options will support improvement of water quality

		Catchment scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Agri-environment options will support improvement of water quality	What is the total area of agri-environment options within catchments of waterbodies of Poor Overall status? What is the total area of agri-environment options designed to address water quality within the Countryside Stewardship priority areas for water? Matrix agri-environment scheme options for soil protection will be focussed in Water Quality Priority Areas?	-Which options are appropriate for each failure (e.g. SSSI)? -This would be good to assess if there is a very specific list of options for each water quality failure (there is in the CS manual)	-Ranking of sensitivities SSSIs -The CS manual contains a list of options which are identified as being able to address WFD pressures	-CSF modelling -Wet weather survey (which help to identify pathways) -EA monitoring	-Responses can be delayed	-Water quality site [sic] data in targeting machine

		Farm-scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the farm-scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Agri-environment options will support improvement of water quality	What is the total area of agri-environment options within catchments of waterbodies of Poor Overall status? What is the total area of agri-environment options designed to address water quality within the Countryside Stewardship priority areas for water? Matrix agri-environment scheme options for soil protection will be focussed in Water Quality Priority Areas?	-Where is woodland (within parcels)? i.e. is it in the right place? -Where all water priority options should be placed within the landscape e.g. at the source, along the pathway or protecting the receptor	-Review of individual agreements -Are options actually sited correctly i.e. source, pathways, receptor	-Site visit -Modelling/remote sensing -Farm visits	-At the start of the agreement. If not effectively sited then they are effectively pointless	-Eventually would appear on databases e.g. new woodland

6. Flexibility in implementation of agri-environment options will allow for more adaptive management

		Catchment scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Flexibility in implementation of agri- environment options will allow for more adaptive management -Flexibility limited by scheme architecture and EU legislation -Does having increased flexibility improve scheme outcomes?	Not covered at national-scale	-Timing -Prescriptions -Sensitivity	-Advisors	-Ability to amend agreements	-5 years (with the option to review/renew)	-Sensitivity is important at the national-scale i.e. timings/seasonality, prescription choice -Flexibility of schemes is key, including the influence of changing climate/weather and the ability (and identification) of when/where derogations have been used -ES seen as restrictive -Separate study to look at the flexibility/restrictions of existing prescriptions

		Farm-scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the farm-scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Flexibility in implementation of agri- environment options will allow for more adaptive management -Locality will determine flexibility of management -Check what the amendment process is for CS	Not covered at national-scale	-Effect of flexibility on outcomes -Have you experienced any problems in implementing an option (e.g. due to weather etc.)?	-Patterns of derogation (linked to changes in mean temperature and/or rainfall) -Farmer/land manager surveys and/or interviews -Amendments to agreements/change of options	-GENESIS (for identifying derogations) -GENESIS reporting is now on hold – we would therefore probably have to use a bespoke assessment -GENESIS has now been superseded by Sity agri [sic]	-Depending in existing frequency of monitoring (i.e. meetings with advisors and/or other existing contact) -Annual desk-based assessment to identify the frequency of derogations	-Learning through doing

7. Agri-environment options which accommodate change will support adaptation

		Catchment scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Agri-environment options which accommodate change will support adaptation	Not covered at national-scale	-Relevant for water				

		Farm-scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the farm-scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Agri-environment options which accommodate change will support adaptation e.g. Flooding, watercourse management, drought	Not covered at national-scale	-What has changed and how can the option be amended and/or replaced? -Is the change accommodated for? Yes for Section 41, perhaps not if causes problems. -Use future envelope models in relation to priority species. There have been cases for species removal	-Are advisors on the lookout for change? -Do advisors have the time? -Switch between mechanisms – has CCA influenced? -Mosaic approach management for species > recognise	-Site visit on changeover of agreement -Ecological site classification	-Easier as agreements change (e.g. every 5 years)	-How much freedom is there in option implementation (e.g. option choice)?

8. Creation and restoration options will be focussed on areas with high habitat potential

		Catchment scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the catchment scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Creation and restoration options will be focussed on areas with high habitat potential	What is the proportion and total area of creation and restoration options within the Outcome 1D potential areas?	-What other habitats (not part of ID) coincide with habitat potential areas? -Are the options currently employed linked to existing restoration plans? -Of options located in habitat potential areas, what is the number contributing to individual habitats? -Need to take this further. Habitat potential can be large but if you combine habitat fragmentation it gives a better local zone for targeting	-Woodlands for Water -Wetland Vision (RSPB) -Soils data (1D uses these) -'Potential' is a broad term. It could include: past history/management, soils, proximity to existing habitat, years since it was in better condition and/or management, existing habitat or vegetation	-Restoration and/or Alignment Plans (will define key criteria which can be assessed against) -Shoreline Management Plan	-5 years	-The same plot of land can potentially be several habitats e.g. acid grassland, heathland and/or woodland. There are both opportunities and clashes

		Farm-scale				
National-scale hypothesis	**National-scale question**	**Monitoring question at the farm-scale**	**Data required to answer question**	**Data collection method (links to existing monitoring / datasets?)**	**Frequency of monitoring**	**Comments**
Creation and restoration options will be focussed on areas with high habitat potential	What is the proportion and total area of creation and restoration options within the Outcome 1D potential areas?	-Are/can creation/restoration be linked to underlying ecosystem processes? -How many key ecosystem processes have been met on land parcel X/Y? -Need to include actions to restore blanket bog – blocking drainage, phasing out rotational burning	-Proxies e.g. grip blocking -Woodland Management Plans	-Farm-scale assessment via Advisors -New surveys		-Training and guidance for Advisors is required before implementing -Outcomes 1A-C are already well defined, this is less the case for 1D

Dr. Paul Munday
Atkins Ltd.
Western House (Block C)
Peterborough Business Park
Lynch Wood
Peterborough
Cambridgeshire
PE2 6FZ

Email: Paul.Munday@atkinsglobal.com
Telephone: (01733) 366900
Direct telephone: (01733) 366917