Land Use Policy Group

The UK statutory conservation, countryside and environment agencies

Estimating the Scale of Future Environmental Land Management Requirements for the UK

Cao, Y., Elliott, J., McCracken, D., Rowe, K., Whitehead, J. and Wilson L.

December 2009

www.lupg.org.uk

The Land Use Policy Group
The Land Use Policy Group (LUPG) of the UK statutory nature conservation, countryside and environment agencies comprises the Countryside Council for Wales, Natural England, Environment Agency, Northern Ireland Environment Agency, Joint Nature Conservation Committee and Scottish Natural Heritage.

The LUPG aims to advise on policy matters of common concern related to agriculture, woodlands and other rural land uses. It seeks to improve understanding of the pros and cons of policy mechanisms related to land use, particularly farming and forestry; to develop a common view of desirable reforms to existing policies; and to promote these views.
www.lupg.org.uk

Countryside Council for Wales
The Countryside Council for Wales champions the environment and landscapes of Wales and its coastal waters as sources of natural and cultural riches, as a foundation for economic and social activity, and as a place for leisure and learning opportunities. It aims to make the environment a valued part of everyone's life in Wales.
www.ccw.gov.uk

Natural England
Natural England is the statutory body working to conserve and enhance England's natural environment, for its intrinsic value, the wellbeing and enjoyment of people and the economic prosperity that it brings. Its role is to ensure that England's unique natural environment, including its land, flora and fauna, freshwater and marine environments, geology and soils, are protected and improved. Natural England also has the responsibility to help people enjoy, understand and access the natural environment.
www.naturalengland.org.uk

Scottish Natural Heritage
Scottish Natural Heritage (SNH) is a government body established to secure conservation and enhancement of Scotland’s unique and valued natural heritage – the wildlife, habitats and landscapes that have evolved in Scotland through long partnership between people and nature. SNH advises on policies and promotes projects that aim to improve the natural heritage and support its sustainable use. Its aim is to help people to enjoy Scotland’s natural heritage responsibly, understand it more fully and use it wisely so it can be sustained for future generations.
www.snh.org.uk

The Environment Agency
The Environment Agency (EA) is the leading public organisation for protecting and improving the environment in England and Wales. The EA achieves this by regulating industry, waste and water quality; managing flood risk and water resources, and improving wildlife habitats in addition to many other activities. The EA also monitors the environment, and makes the information that it collects widely available.
www.environment-agency.gov.uk

Northern Ireland Environment Agency
The Northern Ireland Environment Agency takes the lead in advising on, and in implementing, the Government's environmental policy and strategy in Northern Ireland. The Agency carries out a range of activities, which promote the Government's key themes of sustainable development, biodiversity and climate change. Our overall aims are to protect and conserve Northern Ireland's natural heritage and built environment, to control pollution and to promote the wider appreciation of the environment and best environmental practices.
www.ni-environment.gov.uk

Joint Nature Conservation Committee
The Joint Nature Conservation Committee (JNCC) is the statutory adviser to Government on UK and international nature conservation. Its work contributes to maintaining and enriching biological diversity, conserving geological features and sustaining natural systems.
JNCC delivers the UK and international responsibilities of the four country nature conservation agencies - Council for Nature Conservation and the Countryside, the Countryside Council for Wales, Natural England and Scottish Natural Heritage.
www.jncc.gov.uk

Disclaimer
This report was produced by the authors on behalf of the Land Use Policy Group (LUPG). The views expressed within the report are those of the contractors and do not necessarily reflect the views of the agencies within LUPG.

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Land Use Policy Group Foreword

The Land Use Policy Group (LUPG) of the UK statutory nature conservation, countryside and environmental agencies provides advice to, but is independent of, Government.

A key consideration for the EU Budget and the future Common Agricultural Policy will be identifying the expenditure needed to achieve defined public environmental objectives.

The purpose of this research was to identify indicators capable of being used at the UK level as the basis for estimating the scale of environmental land management activity necessary to meet current policy objectives. The contractors were then asked to estimate how much it might cost to deliver the management required. This was a challenging exercise. To the best of our knowledge, it had never before been attempted for the UK. Inevitably the work incorporated a number of major assumptions which need to be fully understood when interpreting the results. In particular:

The costs presented in this report do not make allowance for:

- The impact of removing Single Farm Payment (SFP) and Less Favoured Area (LFA) payments. This study assumes that such payments are removed but does not address the impact of their removal on the economic viability of farm businesses, nor does it consider any wider socio-economic implications. It assumes that an economically viable agricultural sector remains to deliver the land management required. Despite decoupling there continues to be a cross-subsidy effect from SFP payments, especially in the extensive livestock sectors. Recent economic modelling tends to confirm this, suggesting that most UK livestock production would be uneconomic if the SFP (and the other market mechanisms associated with the CAP) were removed[1] Significant additional funding would be needed to support the costs of farming in these circumstances in order to deliver environmental objectives; in the UK LFA alone, for example, the existing SFP and LFA payments are approximately £1bn. However, costs have been included for those elements of management which go beyond the regulatory baseline, but which are currently supported by the cross-compliance requirements attached to direct payments under Pillar 1 (where these management requirements are required to achieve one or more of the environmental policy objectives).

- The advice and training needed to support delivery has not been included. The value of advice and training in supporting enhanced delivery from agri-environment schemes is increasingly being recognised.

[1] Moss J.E., Patton M., Zhang L., Kim In Seck, Binfield J. and Westhoff P. (2009). Impact of HM Treasury/Defra's Vision for the Common Agricultural Policy on Agriculture in the UK, UK-FAPRI Project Working Paper No. 16.

- The potential delivery models and cost of delivery (administration and project officer support) associated with the proposed levels of intervention have not been considered as part of this work.

The costs shown in this report are also sensitive to a number of other assumptions (which are set out in full in the report). The key ones are highlighted here:

- An assumption that incentives (such as agri-environment schemes) will be the primary delivery mechanism. There has been no attempt to test interventions to see if they could be delivered more effectively by other mechanisms.

- Existing income forgone calculations, which are the basis of current scheme payments, have been used to calculate land management costs. Average costs have been used, which mask significant variations in payment rates between UK countries reflecting different farm structures, systems and costs. Additionally, no attempt has been made to adjust the income forgone calculations to reflect anticipated production costs/margins in the future.

- For some policy objectives, for example resource protection and climate change adaptation and mitigation, the range of existing scheme options (with cost data) is very limited and estimates do not, therefore, reflect all of the management likely to be needed. In particular, where our evidence base on the effectiveness of alternative management practices is less well developed, the cost of the management required to achieve some objectives may be significantly different to that estimated here.

- The availability of suitable spatial data (at a UK scale) has meant that the indicators selected to represent the areas relevant for some policy objectives are not always the best available in individual countries.

Taken together the overall impact of these assumptions means that the costs we have presented may significantly underestimate the total funding necessary within the UK. Nevertheless, our work indicates that the scale of the environmental land management challenge is substantial (in excess of three times that currently available from existing CAP Pillar 2 allocations - but still less than the total current spend on Pillars 1 and 2 combined). The scale of need is hardly surprising bearing in mind that most of the environmental services required by wider society (including the management of carbon, water, biodiversity and landscapes) are currently unrewarded by conventional markets. It is evident that much more work remains to be done before we can fully calculate the true costs of all of the management required, as well as the necessary delivery systems. Nevertheless, we trust that this report will contribute to the debate, not least by providing a methodological framework and identifying the wide range of assumptions that needs testing in future. It would be helpful to see similar exercises undertaken in other member states, especially those with significantly different agricultural sectors and environmental objectives.

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Estimating the Scale of Future Environmental Land Management Requirements for the UK

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0936648

Suggested citation for this report

Cao, Y., Elliott, J., McCracken, D., Rowe, K., Whitehead, J. and Wilson L. (2009) Estimating the Scale of Future Environmental Land Management Requirements for the UK. Report to the Land Use Policy Group. ADAS UK Ltd and Scottish Agricultural College.

Acknowledgements

The authors would like to thank the project steering group, namely Stephen Chaplin and Jonathan Little (Natural England), Maria de la Torre and Ralph Blaney (Scottish Natural Heritage), Sarah Hetherington (Countryside Council for Wales), Fiona Mulholland (Northern Ireland Environment Agency) and Victoria Sturt and Jane James (Environment Agency) for providing datasets and direction throughout the project. Thanks also to Dr Richard Crowe (Department of Agriculture and Rural Development NI) for providing N Ireland Countryside Management Scheme costing information.

Abbreviations

AES	Agri- environment scheme
AONBs	Areas of Outstanding Natural Beauty
ASSI	Areas of Special Scientific Interest
BAP	Biodiversity Action Plan
CAP	Common Agricultural Policy
CCW	Countryside Council for Wales
ES	Environmental Stewardship
ELS	Entry Level Stewardship
ESA	Environmentally Sensitive Areas
EU	European Union
GHG	Green House Gas
HLS	Higher Level Stewardship
HNV	High Nature Value Farmland
LFA	Less Favoured Area
LUPG	Land Use Policy Group
MAGIC	Multi- Agency Geographic Information for the Countryside
NICMS	Northern Ireland Countryside Management Scheme
NIEA	Northern Ireland Environment Agency
NSAs	National Scenic Areas
RDP	Rural Development Programme
RDR	Rural Development Regulation
SNH	Scottish Natural Heritage
SSSI	Sites of Special Scientific Interest
SUDS	Sustainable Urban Drainage Systems
WFD	Water Framework Directive

Executive Summary

Estimating the scale of expenditure needed to effectively address environmental issues is a key consideration for influencing the ongoing review of the EU Budget and for influencing future reform of the Common Agricultural Policy (CAP). The primary purpose of this research was to identify indicators capable of being used at the UK level as the basis for estimating the scale of environmental land management activity necessary to meet current policy objectives. The contractors were also asked to estimate how much it might cost to deliver the management required.

The policy scenario used as a context for this work is a reformed CAP with no Pillar 1 support to farming as modelled by ADAS et al (2008)[2]. ADAS's study anticipates a significant restructuring of agriculture over time to a lower cost base in response to loss of Single Payment and an increase in the area of land 'out of agriculture' due to lack of economic viability. The scenario represents a useful policy context for this work, i.e. the scale of funding that might be needed to meet defined public environmental objectives. However, this study is based on existing environmental priorities and scheme data and does not, therefore, account for:

- changes to Pillar 2 scheme costs under a reformed CAP;
- the costs of addressing issues not adequately represented in the current Pillar 2 schemes;
- the costs of maintaining high nature value farming systems in areas where farming might not be economically viable in the absence of Pillar 1 and LFA support;

Costs have been included for those elements of management which go beyond the regulatory baseline, but which are currently supported by the cross-compliance requirements attached to direct payments under Pillar 1 (where these management requirements are required to achieve one or more of the policy objectives). The results therefore provide an indication of the scale of future environmental land management requirements, taking account of a wide range of objectives in a synergistic way and examining all four UK administrations from the perspective on both coverage and cost.

Methodology and assumptions

The methodology was based around two key elements of work, firstly relating to the scale and location of environmental need and secondly allocating agri-environment scheme (AES) options to deliver the necessary land management. The first workstream involved identifying suitable datasets (indicators) which would represent the objectives, both in absolute terms (hectares of land or length of linear feature) and spatially where possible. The second workstream used the existing agri-environment options across the UK countries to inform a set of 'generic' options which could deliver the desired environmental outcomes.

A key aspect of the work was mapping overlaps between indicators and making an assessment of whether a single management option could meet the demands of both, or whether two overlapping options were needed and whether in some instances one option

[2] ADAS, SAC and RPA (2008) Estimating the Environmental Impacts of Pillar I Reform and the Potential Implications for Axis II funding. Final report to Defra and Natural England.
https://statistics.defra.gov.uk/esg/reports/Impacts%20of%20Pillar%20I%20Reform%20Final%20Report.pdf
Based on HM Treasury and Defra (2005). A Vision of the Common Agricultural Policy.
http://www.defra.gov.uk/farm/policy/capreform/pdf/vision-for- cap.pdf

should take precedence. This process has been key to the scale and distribution of costs between objectives.

Inevitably the work incorporated a number of major assumptions which need to be fully understood when interpreting the results. In particular:

- The costs presented in this report make no allowance for the impact of removal of cross-subsidisation effects of Single Farm Payment (SFP) and LFA payments on retaining land in agriculture.
- No specific allowance for the advice and training needed to support delivery has been included. The value of advice and training in supporting enhanced delivery from agri-environment schemes is increasingly being recognised.
- The potential delivery costs (administration and project officer support) associated with the proposed levels of intervention have not been considered.

The costs shown in this report are also sensitive to a number of other assumptions, all of which are detailed in full in the main text. The overall impact of these assumptions means that the costs we have presented are likely to underestimate the total funding that is necessary.

Results

The key results for indicator areas are summarised in Table 1.

Table 1: Indicator areas for key environmental objectives by UK country (hectares)

Objective	England	Scotland	Wales	N. Ireland	UK	% Total
Biodiversity*	10,353,804	6,481,901	979,578	684,693	**18,499,976**	38%
Landscape*	2,583,778	691,590	528,945	166,063	**3,970,376**	8%
Climate change mitigation	4,069,627	2,385,862	693,632	858,284	**8,007,405**	17%
Flood risk management	1,363,067	390,290	117,824	147,802	**2,018,983**	4%
Farm historic environment	36,357	10,096	3,343	8,697	**58,493**	0%
Soil quality	1,999,625	395,545	7,617	12,758	**2,415,545**	5%
Water quantity	3,472,680	**	**	**	**3,472,680**	7%
Resource protection	6,923,544	1,158,441	1,065,286	607,297	**9,754,568**	20%

* Area data excludes linear features (hedgerows and stone walls); these are allowed for in the costing in table 2

** Indicator currently only applies to England but may extend to other regions by 2020 due to climate change; the EAW Water Management strategy for Wales which says in dry summers South East Wales already has a water management problem. Additionally, actions may be given priority in terms of resource efficiency

The analysis suggests that biodiversity, climate change and resource protection account for the greatest land area needing management under AES options. However, there are significant overlaps between indicators, both within and between objectives and areas have been adjusted accordingly. This required judgement on which indicators take precedence in the overlap areas. In the process of dealing with overlaps, large areas associated with work on climate change and resource protection overlap with those needing to be managed for biodiversity. The latter has been given precedence in terms of identifying suitable management options, given that they are spatially fixed and AES options for biodiversity are sufficiently broad to cover other objectives. Thus where a single AES option can deliver both objectives, spend is attributed to biodiversity, exaggerating its relative significance.

The second key task was to estimate the cost of meeting land management requirements in indicator areas using AES options. For the costing exercise, a generic AES option was

allocated to each indicator and costed, taking account of the range of AES payment rates across the UK. AES option costs were generally higher for biodiversity than for climate change and resource protection. In practice, AES options for climate change and resource protection are not well developed at present and could be much more significant in future and more costly in terms of income forgone. The results are summarised in Table 2.

Table 2: Annual cost of AES options to deliver environmental policy objectives (£ million)

	England	Scotland	Wales	N. Ireland	UK	% Total
Biodiversity	624.4	250.2	71.9	56.7	**1,003**	51%
Landscape	107.3	85.5	18.8	8.5	**220**	11%
Climate change mitigation	172.9	37.3	28.7	31.3	**270**	14%
Flood risk management	43.2	27.9	14.2	7.1	**92**	5%
Farmland historic environment	9.1	2.5	0.8	2.2	**15**	1%
Soil quality	94.6	18.4	0.3	0.6	**114**	6%
Water quantity	69.5	**	**	**	**69**	3%
Resource protection	99.1	18.9	23.2	12.9	**154**	8%
Public access	38.0	3.5	6.6	0.2	**48**	2%
Total	**1,258**	**444**	**165**	**119**	**1,986**	
% Total	63%	22%	8%	6%		

** Indicator currently only applies to England but may extend to other regions by 2020 due to climate change; additionally actions may be given priority in terms of resource efficiency

Linear features also have a significant impact on the relative significance of costs of delivering landscape objectives (hedgerows) and farm historic environment objectives (stone walls). See Table 11.

The total cost of meeting publicly defined environmental objectives in the UK is estimated at just under £2 billion per year; this figure could vary from £1-3 billion due to variation in the cost of similar AES options across countries and the extent to which existing scheme options are sufficient to achieve the full range of policy objectives. The costings are indicative only, given the numerous caveats, but suggest a significant increase over current budgets. Further research is needed to understand the scale and nature of all of the management inputs required as well as the scope for delivering multiple environmental objectives from single AES options.

Conclusions

Overall, this was a challenging exercise; to the best of our knowledge, it had never before been attempted for the UK. It suggests an overall level of Pillar 2 requirement of £1-3 billion, which is well above current levels, despite using current indicator areas and AES option payment rates. This suggests that addressing any additional challenges in CAP reform would further increase the figure.

A key finding is the extent to which indicators overlap and the scope for improved efficiency by delivering multiple objectives through a single land management option. In practice, achieving such synergies will require a high level of 'joined-up' thinking in terms of policy design and implementation. This will also need to account for policy conflicts and synergies where a single option cannot address all needs. As increasing priority is given to tackling climate change, resource protection and flood mitigation, more attention should be given to the design of AES options which deliver these objectives in synergy with more established priorities such as biodiversity, landscape and public access to the countryside.

Crynodeb Gweithredol

Mae amcangyfrif faint o wariant sydd ei angen er mwyn mynd i'r afael yn effeithiol â materion amgylcheddol yn ystyriaeth bwysig er mwyn dylanwadu ar yr adolygiad cyfredol o Gyllideb yr Undeb Ewropeaidd ac er mwyn dylanwadu ar ddiwygiadau i'r Polisi Amaethyddol Cyffredin (PAC) yn y dyfodol. Prif bwrpas y gwaith ymchwil hwn oedd canfod dangosyddion y gellid eu defnyddio yn y Deyrnas Unedig fel sail i'r gwaith o amcangyfrif faint o weithgareddau rheoli tir amgylcheddol sydd eu hangen er mwyn cyflawni'r amcanion polisi presennol. Gofynnwyd i'r contractwyr amcangyfrif hefyd faint fyddai cost cyflawni'r gwaith rheoli angenrheidiol.

Y senario polisi a ddefnyddiwyd fel cyd-destun i'r gwaith hwn yw PAC diwygiedig heb unrhyw gefnogaeth Colofn 1 i ffermio yn unol â model ADAS et al (2008).[3] Mae astudiaeth ADAS yn rhagweld ailstrwythuro sylweddol dros gyfnod mewn amaethyddiaeth gan greu sail cost is mewn ymateb i golli'r Taliad Sengl a chynnydd yn arwynebedd y tir nad yw'n cael ei ddefnyddio i ddibenion amaethyddol oherwydd diffyg hyfywedd economaidd. Mae'r senario'n rhoi cyd-destun defnyddiol i'r gwaith hwn, h.y. faint o arian y mae'n bosibl y bydd ei angen er mwyn cyflawni amcanion amgylcheddol cyhoeddus diffiniedig. Serch hynny, mae'r astudiaeth hon yn seiliedig ar flaenoriaethau amgylcheddol a data cynlluniau sy'n bodoli heddiw ac, o ganlyniad, nid yw'n ystyried:

- newidiadau i gostau cynlluniau Colofn 2 dan PAC diwygiedig;
- costau mynd i'r afael â materion nad ydynt yn cael eu mynegi'n ddigonol yn y cynlluniau Colofn 2 presennol;
- costau cynnal systemau ffermio gwerthfawr o safbwynt natur mewn ardaloedd lle mae'n bosibl na fyddai ffermio'n economaidd hyfyw heb gymorth Colofn 1 ac Ardaloedd Llai Ffafriol.

Mae costau wedi cael eu cynnwys ar gyfer yr elfennau hynny o reolaeth sy'n mynd y tu hwnt i'r llinell sylfaen reoleiddiol, ond sy'n cael eu cefnogi ar hyn o bryd gan y gofynion trawsgydymffurfio sydd ynghlwm wrth daliadau uniongyrchol dan Golofn 1 (lle mae angen y gofynion rheoli hyn er mwyn cyflawni un neu ragor o'r amcanion polisi). Mae'r canlyniadau felly'n rhoi rhyw syniad yngl n â'r gofynion rheoli tir amgylcheddol a fydd yn berthnasol yn y dyfodol, gan ystyried ystod eang o amcanion mewn modd synergaidd ac edrych ar bob un o'r pedair gweinyddiaeth sydd yn y Deyrnas Unedig o safbwynt arwynebedd a chost.

Methodoleg a thybiaethau

Roedd y fethodoleg yn seiliedig ar ddwy elfen allweddol; yn gyntaf, maint a lleoliad yr angen amgylcheddol, ac yn ail, dyrannu dewisiadau cynlluniau amaeth-amgylcheddol er mwyn cyflawni'r gwaith rheoli tir angenrheidiol. Roedd y ffrwd waith gyntaf yn ymwneud â dynodi setiau data addas (dangosyddion) a fyddai'n cynrychioli'r amcanion, mewn termau absoliwt (hectarau o dir neu hyd nodwedd linellog) a hefyd mewn termau gofodol lle'r oedd hynny'n bosibl. Roedd yr ail ffrwd waith yn defnyddio'r dewisiadau amaeth-amgylcheddol presennol ym mhob un o wledydd y Deyrnas Unedig fel sail i set o ddewisiadau 'generig' a allai gyflawni'r canlyniadau amgylcheddol y dymunid eu gweld.

[3] ADAS, SAC ac RPA (2008) *Estimating the Environmental Impacts of Pillar I Reform and the Potential Implications for Axis II funding*. Adroddiad terfynol i Defra a Natural England.
https://statistics.defra.gov.uk/esg/reports/Impacts%20of%20Pillar%20I%20Reform%20Final%20Report.pdf
Yn seiliedig ar adroddiad ar y cyd gan Drysorlys Ei Mawrhydi a Defra (2005). *A Vision of the Common Agricultural Policy*.
http://www.defra.gov.uk/farm/policy/capreform/pdf/vision-for-_cap.pdf

Elfen allweddol o'r gwaith oedd mapio unrhyw orgyffwrdd rhwng dangosyddion ac asesu a allai un dewis rheoli fodloni gofynion y ddau, ynteu a oedd angen dau ddewis a oedd yn gorgyffwrdd, ac a ddylid rhoi blaenoriaeth i un dewis mewn rhai achosion. Mae'r broses hon wedi bod yn allweddol i faint a dosbarthiad costau rhwng amcanion.

Mae'n anorfod bod y gwaith wedi ymgorffori nifer o dybiaethau pwysig, ac mae angen dealltwriaeth drylwyr o'r rhain wrth ddehongli'r canlyniadau e.e.

- Nid yw'r costau a roddir yn yr adroddiad hwn yn ystyried sut y byddai dileu effeithiau traws-sybsideiddio'r Taliad Sengl a thaliadau Ardaloedd Llai Ffafriol yn effeithio ar ddal i ddefnyddio tir ar gyfer amaethyddiaeth.
- Ni chynhwyswyd lwfans benodol ar gyfer y cyngor a'r hyfforddiant sydd ei angen i gefnogi'r gwaith cyflawni. Mae gwerth cyngor a hyfforddiant er mwyn cynorthwyo cynlluniau amaeth-amgylcheddol i gyflawni mwy yn cael ei gydnabod fwy a mwy.
- Nid yw'r costau cyflawni posibl (gwaith gweinyddol a chymorth swyddog prosiect) sy'n gysylltiedig â'r lefelau ymyrryd arfaethedig wedi cael eu hystyried.

Mae'r costau a ddangosir yn yr adroddiad hwn yn sensitif i nifer o dybiaethau eraill hefyd. Ceir manylion llawn am bob un o'r tybiaethau hyn yng nghorff yr adroddiad. Mae effaith gyffredinol y tybiaethau hyn yn golygu bod y costau rydym wedi'u cyflwyno'n debygol o fod yn amcangyfrif isel o gyfanswm y cyllid sydd ei angen.

Canlyniadau

Ceir crynodeb o'r canlyniadau allweddol ar gyfer ardaloedd dangosyddion yn Nhabl 1.

Tabl 1: Ardaloedd dangosyddion ar gyfer amcanion amgylcheddol allweddol yng ngwledydd y Deyrnas Unedig (hectarau)

Amcan	Lloegr	Yr Alban	Cymru	Gogledd Iwerddon	Y Deyrnas Unedig	% o'r Cyfanswm
Bioamrywiaeth*	10,353,804	6,481,901	979,578	684,693	**18,499,976**	38%
Tirwedd*	2,583,778	691,590	528,945	166,063	**3,970,376**	8%
Lliniaru newid yn yr hinsawdd	4,069,627	2,385,862	693,632	858,284	**8,007,405**	17%
Rheoli perygl o lifogydd	1,363,067	390,290	117,824	147,802	**2,018,983**	4%
Amgylchedd hanesyddol ffermydd	36,357	10,096	3,343	8,697	**58,493**	0%
Ansawdd pridd	1,999,625	395,545	7,617	12,758	**2,415,545**	5%
Ansawdd dŵr	3,472,680	**	**	**	**3,472,680**	7%
Diogelu adnoddau	6,923,544	1,158,441	1,065,28	607,297	**9,754,568**	20%

* Nid yw data'r ardaloedd yn cynnwys nodweddion llinellog (gwrychoedd a waliau cerrig); ystyrir y rhain yn y costau yn Nhabl 2.

** Dim ond i Loegr y mae'r dangosydd yn berthnasol ar hyn o bryd ond gallai ymestyn i ranbarthau eraill erbyn 2020 o ganlyniad i newid yn yr hinsawdd; mae Strategaeth Rheoli Dŵr Asiantaeth yr Amgylchedd Cymru yn nodi bod gan Dde -ddwyrain Cymru broblem rheoli dŵr eisoes yn ystod hafau sych. Yn ychwanegol at hyn, gellid rhoi blaenoriaeth i gamau gweithredu o safbwynt effeithlonrwydd adnoddau.

Mae'r dadansoddiad yn awgrymu mai bioamrywiaeth, newid yn yr hinsawdd a diogelu adnoddau sydd â'r arwynebedd tir mwyaf y mae angen ei reoli dan ddewisiadau cynlluniau amaeth-amgylcheddol. Serch hynny, mae cryn dipyn o orgyffwrdd rhwng dangosyddion, o fewn amcanion, a rhwng gwahanol amcanion, ac addaswyd arwynebedd yn unol â hynny. O ganlyniad, roedd angen penderfynu pa ddangosyddion sy'n cael blaenoriaeth yn yr ardaloedd lle mae gorgyffwrdd. Yn y broses o ymdrin â gorgyffwrdd, mae ardaloedd helaeth sy'n gysylltiedig â gwaith ym maes newid hinsawdd a diogelu adnoddau'n gorgyffwrdd â'r

rhai hynny y mae angen eu rheoli ar gyfer bioamrywiaeth. Rhoddwyd blaenoriaeth i'r olaf o ran dynodi dewisiadau rheoli addas, oherwydd eu gofod sefydlog, a chan fod dewisiadau cynlluniau amaeth-amgylcheddol ar gyfer bioamrywiaeth yn ddigon eang i gynnwys amcanion eraill. Felly, lle gall dewis cynllun amaeth-amgylcheddol sengl gyflawni'r ddau amcan, priodolir gwariant i fioamrywiaeth, gan roi mwy o bwyslais ar ei bwysigrwydd cymharol.

Yr ail dasg allweddol oedd amcangyfrif cost bodloni gofynion rheoli tir mewn ardaloedd dangosyddion gan ddefnyddio dewisiadau cynlluniau amaeth-amgylcheddol. Ar gyfer yr ymarfer costio, dyrannwyd dewis cynllun amaeth-amgylcheddol generig i bob dangosydd a'i gostio, gan ystyried yr ystod o gyfraddau talu mewn cynlluniau amaeth-amgylcheddol ledled y Deyrnas Unedig. Roedd costau dewisiadau cynlluniau amaeth-amgylcheddol yn uwch ar y cyfan ar gyfer bioamrywiaeth nag ar gyfer newid yn yr hinsawdd a diogelu adnoddau. Yn ymarferol, nid yw dewisiadau cynlluniau amaeth-amgylcheddol ar gyfer newid yn yr hinsawdd a diogelu adnoddau wedi'u datblygu'n dda iawn ar hyn o bryd, a gallent fod yn llawer mwy sylweddol yn y dyfodol ac yn fwy costus o ran incwm a gollwyd. Ceir crynodeb o'r canlyniadau yn Nhabl 2.

Tabl 2: Cost flynyddol dewisiadau cynlluniau amaeth-amgylcheddol er mwyn cyflawni amcanion polisi amgylcheddol (£ miliwn)

	Lloegr	Yr Alban	Cymru	Gogledd Iwerddon	Y Deyrnas Unedig	% o'r Cyfanswm
Bioamrywiaeth	624.4	250.2	71.9	56.7	**1,003**	51%
Tirwedd	107.3	85.5	18.8	8.5	**220**	11%
Lliniaru newid yn yr hinsawdd	172.9	37.3	28.7	31.3	**270**	14%
Rheoli perygl o lifogydd	43.2	27.9	14.2	7.1	**92**	5%
Amgylchedd hanesyddol tir addas i'w ffermio	9.1	2.5	0.8	2.2	**15**	1%
Ansawdd pridd	94.6	18.4	0.3	0.6	**114**	6%
Ansawdd dŵr	69.5	**	**	**	**69**	3%
Diogelu adnoddau	99.1	18.9	23.2	12.9	**154**	8%
Mynediad cyhoeddus	38.0	3.5	6.6	0.2	**48**	2%
Cyfanswm	**1,258**	**444**	**165**	**119**	**1,986**	
% o'r Cyfanswm	63%	22%	8%	6%		

** Dim ond i Loegr y mae'r dangosydd yn berthnasol ar hyn o bryd ond gallai ymestyn i ranbarthau eraill erbyn 2020 o ganlyniad i newid yn yr hinsawdd; yn ychwanegol at hyn, gellid rhoi blaenoriaeth i gamau gweithredu o safbwynt effeithlonrwydd adnoddau.

Mae nodweddion llinellog hefyd yn cael effaith sylweddol ar bwysigrwydd cymharol costau cyflawni amcanion tirwedd (gwrychoedd) ac amcanion amgylchedd hanesyddol ffermydd (waliau cerrig). Gweler Tabl 11.

Amcangyfrifir bod cyfanswm y gost o gyflawni amcanion amgylcheddol sydd wedi'u diffinio'n gyhoeddus yn y Deyrnas Unedig bron yn £2 biliwn y flwyddyn; gallai'r swm hwn amrywio o £1-3 biliwn o ganlyniad i amrywiad yng nghost dewisiadau cynlluniau amaeth-amgylcheddol tebyg mewn gwahanol wledydd a'r graddau y mae dewisiadau cynlluniau presennol yn ddigonol er mwyn cyflawni'r holl amcanion polisi. Dangosol yn unig yw'r costau, gan fod llawer o gafeatau, ond maent yn awgrymu cynnydd sylweddol o gymharu â'r cyllidebau presennol. Mae angen rhagor o waith ymchwil er mwyn deall maint a natur yr holl fewnbwn rheolaeth sydd ei angen yn ogystal â'r sgôp ar gyfer cyflawni nifer o amcanion amgylcheddol â dewisiadau cynllun amaeth-amgylcheddol sengl.

Casgliadau

Yn gyffredinol, roedd yr ymarfer hwn yn dipyn o her; hyd y gwyddom, nid oedd erioed wedi'i wneud o'r blaen yn y Deyrnas Unedig. Mae'n awgrymu y bydd angen £1-3 biliwn o gyllid Colofn 2, sy'n llawer uwch na'r lefelau presennol, er ein bod wedi defnyddio'r ardaloedd dangosyddion presennol a chyfraddau talu dewisiadau cynlluniau amaeth-amgylcheddol presennol. Mae hyn yn awgrymu y byddai angen mwy fyth o arian er mwyn mynd i'r afael ag unrhyw heriau ychwanegol o ganlyniad i ddiwygio'r PAC.

Un o'r prif ganfyddiadau yw'r graddau y mae dangosyddion yn gorgyffwrdd a'r posibilrwydd y gellid cael gwell effeithlonrwydd drwy gyflawni nifer o amcanion ag un dewis rheoli tir. Yn ymarferol, bydd angen llawer o waith meddwl 'cydgysylltiedig' er mwyn sicrhau cydweithio o'r fath wrth lunio a gweithredu polisïau. Bydd angen ystyried gwrthdaro rhwng polisïau hefyd ynghyd â chydweithio lle nad yw'n bosibl i un dewis roi sylw i'r holl anghenion. Wrth i fynd i'r afael â newid yn yr hinsawdd, diogelu adnoddau a lliniaru llifogydd ddod yn fwy o flaenoriaeth, dylid rhoi mwy o sylw i lunio dewisiadau cynlluniau amaeth-amgylcheddol sy'n cyflawni'r amcanion hyn ar y cyd â blaenoriaethau sydd eisoes wedi sefydlu eu hunain, megis bioamrywiaeth, tirwedd a mynediad cyhoeddus i gefn gwlad.

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1. Introduction

Estimating the scale of the expenditure required to effectively address environmental issues is a key consideration for influencing the EU Budget Review and subsequent Financial Perspective, and for influencing future CAP reform. In the context of the forthcoming EU Budget Review there is also a renewed interest in the rationale for EU level expenditure on a wide range of issues, including environmental expenditure.

The primary purpose of this research is to identify indicators that could be used at the UK level as the basis for deriving estimates for the coverage of environmental land management activity that would be required to deliver a set of defined environmental policy objectives. The second aspect is to generate estimates of the likely cost of delivering this environmental management against a defined baseline.

The policy context for this work is a reformed CAP with no Pillar 1 support to farming as modelled by ADAS *et al* (2008). This anticipates a significant restructuring of agriculture over time to a lower cost base in response to loss of Single Payment and an increase in the area of land 'out of agriculture' due to lack of economic viability. While the scenario represents a useful policy background for estimating the scale of funding needed under Pillar 2 to meet environmental objectives, the indicator areas reflect current priorities rather than a future land use position. Indeed, the policy scenario is one of a number of possible outcomes of ongoing development of CAP policy and restructuring of the agricultural sector due to wider drivers (see ADAS and SAC, 2007[4]).

Government across the UK has a wide range of policies relating to agricultural land use and management in order to limit the environmental impacts of farming and/or to secure a wider set of public goods. These supporting, regulating and cultural ecosystem services are secured in tandem with the primary function of agricultural land use as a means of proving food, fibre, fuel etc. The mechanism for achieving this balance is through a range of policy instruments, including regulation, voluntary actions and economic incentives. This study is concerned with the latter and assumes that the existing regulatory baseline remains unchanged – consequently the delivery of those activities beyond the baseline that are currently supported by cross-compliance are included in the cost estimates (where they are required to deliver the stated policy objectives).

Agri-environment schemes are action-based, time-limited agreements, offering payments to land managers in return for adherence to management prescriptions relating to environmental objectives. The costing exercise uses existing AES options available across the UK and current payment rates to provide an indication of the cost of future environmental land management requirements. No account has been taken of future changes to the payment rate (in the absence of Pillar 1 support) or mechanism (see Schwarz *et al,* 2008)[5] or the costs of maintaining marginal land in farming. Nevertheless, the approach of applying current AES options (and costs) to defined areas on the basis of indicators of need provides a reasonable basis for estimating the future scale of environmental land management requirements. A key

[4] ADAS and SAC (2007) Baseline Projections for Agriculture and implications for emissions to air and water. ADAS research report for Defra

[5] Schwarz, G., Moxey, A., McCracken, D., Huband, S. and Cummins R. (2008) An analysis of the potential effectiveness of a Payment-by-Results approach to the delivery of environmental public goods and services supplied by Agri-Environment Schemes. Report to the Land Use Policy Group, UK, 108pp. Macaulay Institute, Pareto Consulting and Scottish Agricultural College.

issue is the extent of spatial overlap between indicators and the extent to which single AES options can deliver multiple objectives.

1.1 Research requirements

The aim of the research is to identify indicators that could be used as the basis for estimating future coverage and funding requirements for environmental land management in the UK. There are five specific objectives as follows:

1. Indicators:
   - Identify indicators, for which data is readily available, that could be used as the basis for UK wide estimates of the coverage of land required to achieve each of the specified policy objectives (see assumptions), recommending the most suitable.

2. Coverage:
   - Using the selected indicators quantify the area of land in the UK, by region (England, Wales, Scotland, Northern Ireland), where positive environmental management is required, for each policy objective.
   - Quantify the extent of overlaps between the areas of land identified for each policy objective.

3. Scheme-Policy Matrix:
   - Identify the changes in management practice that are likely to be required to achieve each policy objective.
   - Identify the existing scheme options/groups of options that could be used to deliver the management required to achieve each of the policy objectives (this will need to consider the different schemes/options available in England, Wales, Scotland, and Northern Ireland).
   - Identify any gaps and suggest possible scheme options that would be required to address these.

4. Intensity:
   - Estimate the average annual unit cost of environmental land management activity for achieving the different policy objectives assuming the forecast industry structure and existing delivery mechanisms (see assumptions on forecast industry structure at Appendix 2).
   - Consider the extent to which this varies between England, Wales, Scotland and Northern Ireland.
   - Quantify the extent to which delivery of one objective contributes to delivery of others and the extent to which unit costs are reduced under these combinations.

5. Cost:
   - Aggregate the coverage and intensity data to provide an estimate of the total annual cost for each policy objective/sub-objective for each of the UK regions.
   - Aggregate the coverage and intensity data to provide an estimate of the total annual cost for each of the UK regions, adjusting for overlaps where possible.

2. Methodology

The study objectives set out a clear logical set of tasks which lead to an estimate of the policy costs of meeting a set of defined environmental objectives. The two key elements of the work have been the sourcing and mapping of datasets to represent need and a synthesis of existing agri-environment scheme (AES) options to address these needs. These two streams of the research (coverage and intensity) come together in the final stages of the work to provide cost estimates by policy objective and by country. This process has involved a number of substantial assumptions, detailed below and at Appendix 3; as such, the coverage and cost estimates need to be interpreted with care.

Key assumptions are summarised below; each includes a steer on the potential impact of the assumption on the final cost estimates:

1. The scope of policy objectives and sub-objectives are as set out in the brief (Appendix 2). Thus for climate change mitigation, the sub-objective *carbon sequestration* is defined as 'provide energy crops for renewable energy'; *protect existing major carbon stores (peat, wetlands, woodlands, soils)* is a separate sub-objective. The list of greenhouse gases was extended to include methane and ammonia emissions were also mapped. *Low impact*.

2. There is no attempt to capture socio-economic objectives such as maintenance of farming in remote areas, other than where this is driven by an environmental need. Thus, Less Favoured Area (LFA) is not an appropriate indicator. High Nature Value Farmland (HNV)[6], which often occurs in LFAs, is relevant as it relates to conservation value but the concept is not well defined or mapped at present so we have used available designations such as Environmentally Sensitive Areas (ESA) which recognise historic / cultural value as well as wildlife and landscape and BAP priority habitat. *Low impact*.

3. While some policy objectives have a focus on maintaining environmental assets through ongoing active management (as with UK priority habitats / species and carbon stores), for others the emphasis is creation of new assets e.g. increasing landscape permeability/connectivity by establishing buffers/green infrastructure for climate change adaption or water storage to mitigate flood risk. For the former we have quantified and mapped existing assets while for the latter, we have quantified only new assets. *Moderate impact*.

4. The selection of indicators is constrained by the availability of data; thus while there is a broad habitat for 'rivers and streams', national data are only available for UK priority species and habitats[7]. Bird assemblage information for Scotland is not comprehensive as there isn't good information for some areas[8] and the lack of spatial data on biodiversity targets for Scotland and N Ireland is another key data limitation. For policy objectives such as landscape, we have focused on landscape designations such as AONBs/ NSAs and National Parks rather than component features such as woodland, rivers etc. The exception is stone walls which are recognised as a discrete asset in current AES. *High impact*.

[6] The HNV concept has been adopted by the European Commission and Member States are required to ensure that the Axis 2 (Sustainable Land Management) element of their 2007-2013 Rural Development Programmes (RDPs) are targeted at "…biodiversity and preservation of high nature value farming and forestry systems, water and climate change".
[7] http://www.ukbap-reporting.org.uk/search/priority.asp?M=1
[8] http://www.rspb.org.uk/ourwork/conservation/projects/targeting/targeting_maps.asp

5. Where relevant, indicators have been used for more than one policy objective e.g. Coastal & Floodplain Grazing Marsh priority habitat was used as a biodiversity and flood risk (water storage) indicator while woodland was used as a biodiversity and climate change indicator. *Low impact*.

6. Where indicator data was not available, we have used proxy indicators e.g. 'Agricultural demand >100% of available surface water' for the *Water quantity* objective and 'Livestock excreta loads' for the *Reduce water pollution from livestock* objective. Where no indicator data is available e.g. managed retreats, the cost of meeting this objective is not represented in the overall costs. *Moderate impact*.

7. While many indicators can be quantified and most of these mapped spatially, others such as new energy crop plantings and new public access are based on published policy targets (where available) and are not spatially represented. Notably, there is no spatial data for biodiversity targets in Scotland and N Ireland which is a major limitation in terms of the overlap analysis. The selected indicators are detailed at Appendix 3 in terms of rationale and methodology, data source and limitations. *Moderate impact*.

8. Selected indicators are quantified and mapped as at present (2008 data or most recent available), but used to represent the extent of future land management requirements. In practice, a reformed CAP with no Pillar I support would impact on land use (ADAS *et al*, 2008) with consequent change in extent and location of environmental needs (detailed at Appendix 3). The approach does not attempt to account for changes in the extent or location of any indicator on the basis of future policy change or climate change. *High impact*.

9. Where indicators overlap, we have considered whether a single AES option can meet the needs of both objectives, whether one of the priorities takes precedence over the other or whether two separate options are needed in combination. This process is described in Appendix 4. In general, indicators with a statutory requirement such as SSSIs or which are spatially limited such as BAP Priority Habitats take precedence over more generic objectives. *High impact*.

10. Each indicator has been assigned a management prescription, either as a specific AES option from one of the current country programmes or a generic option, which represents a synthesis of relevant options across the countries. AES options relate to discrete management inputs in most cases and are comparable with current 'higher level' stewardship options rather than broad and shallow 'entry level' schemes. While current lower tier schemes make a contribution to a range of environmental objectives, it is assumed that these are captured by the objective-specific actions and as such no additional lower tier schemes are needed. *Moderate impact*.

11. The costing of AES in 2020 is based on current payment rates (which are in turn historic). A reformed CAP may lead to lower incomes from farming *per se* per and a greater explicit reliance on AES payments for public goods. As such the Income Forgone (IF) related to meeting environmental objectives may be lower than at present. The cross-subsidy element of SPS is not relevant to IF but, in some cases, additional funding may be needed to support the full costs of farming where it is no longer economic to farm and land would be out of agriculture e.g. to retain farming in the uplands and remote peripheral areas of the UK. *Moderate impact*.

12. In terms of costing AES activities, we assume that all costs are met in full through Pillar 2. In practice some costs are currently met through other funding streams

e.g. in N Ireland, national funds are used to help bring ASSI sites/features into favourable-recovering status; RDP funds used to provide ongoing management. On the other hand, there is no attempt to meet socio-economic objectives in the costing whereas this is currently the case under LFA support. As such, costs are not directly comparable with current RDP Axis 2 budgets. *Moderate impact*.

13. The climate change adaptation objective is cross-cutting and has not been addressed separately. While some of the challenges of adaptation may be met through actions addressed by the other objectives, there is little evidence on this. Changes to natural ecosystems or those resulting from farming's response to climate change may require significant intervention in terms of land management. *Low-High impact*.

14. No account has been taken of the additional capital costs (such as fencing) required for the implementation of changed grazing regimes etc. *Low impact*.

The research framework used in the study is set out in Figure 1 below:

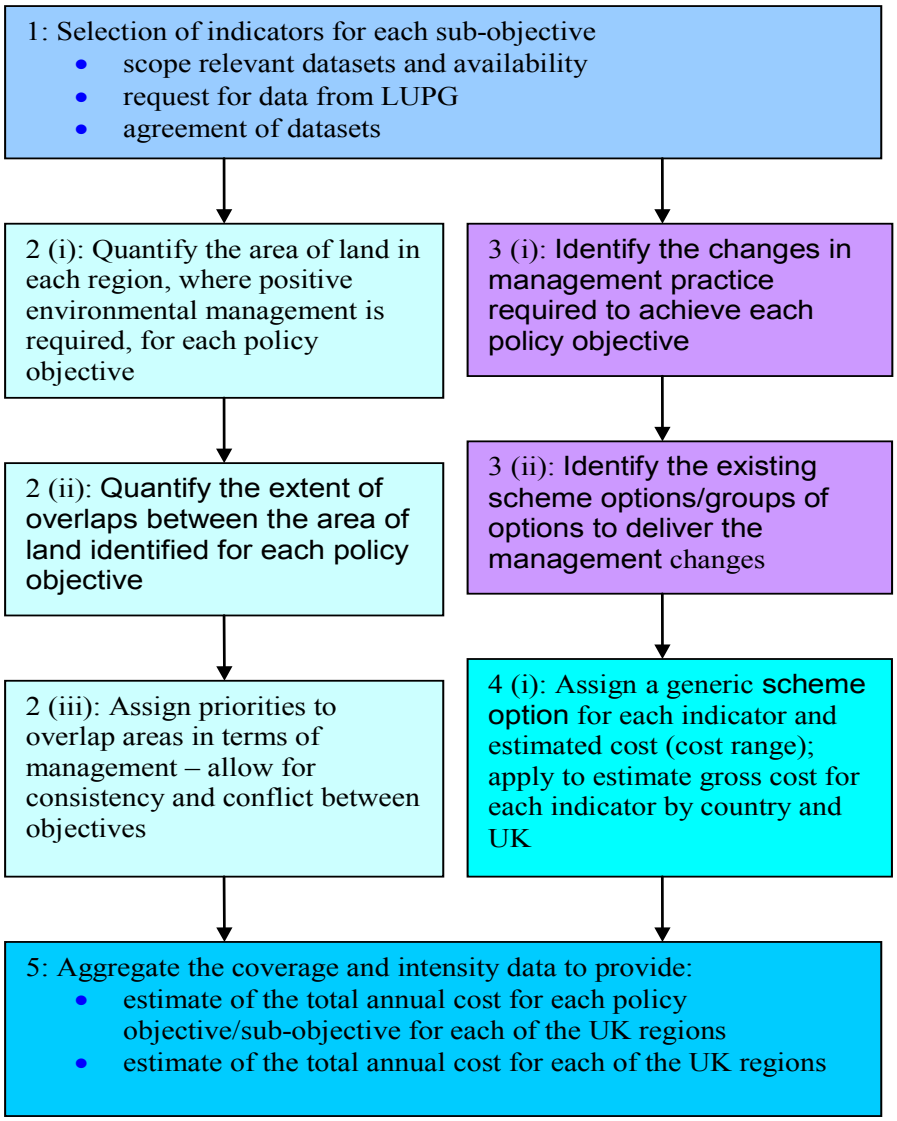


Figure 1: Methodological framework for the study

3. Policy objectives and indicators

A comprehensive list of policy objectives (and sub-objectives) was provided by LUPG (Appendix 2). For each, we identified relevant datasets and considered their suitability for the purpose of this study. For some objectives, notably BAP priority habitats, the indicator is well defined and spatially mapped (in most cases) and the dataset readily available. For others, such as BAP priority species, decisions had to be taken on which components of the dataset to prioritise (which species) and at what scale the intervention is appropriate (see Appendix 3). Subsequently a single indicator (and associated dataset) was selected and agreed with LUPG. These are summarised below in Table 3 along with availability across the four countries.

Table 3: Coverage of indicators by country

Policy objective	Indicators	England	Scotland	Wales	N Ireland
Biodiversity: habitats	Blanket Bog	S	N	S	N
	Cereal field margins	N	N	N	N
	Coastal & Floodplain Grazing marsh	S	N	S	N
	Hedgerows	N	N	N	N
	Lowland Grassland	S	N	S	N
	Lowland Heathland	S	N	S	N
	Lowland Raised Bogs	S	N	S	N
	Lowland wood pasture & parkland	S	N	S	N
	Purple moor grass and rush-pasture	S	N	S	N
	SSSIs (ASSIs in N Ireland)	S	S	S	S
	Upland Grassland	S	N	S	N
	Upland Heathland	S	N	S	N
	Wet woodland	S	N	N	N
	Woodland	S	N	N	N
Biodiversity: species	Arable assemblages	S	S	S	S
	Grassland assemblages	S	S	S	S
Biodiversity: connectivity	3km buffer - habitats / assemblages	S	S	S	S
Biodiversity: woodland creation	Woodland creation (targets)	N	N	N	S
Landscape	Landscape designations	S	S	S	S
	Stone walls	N	N	N	N
Climate change	Energy crop plantings (targets)	N	N	N	N
	Peat carbon stores	S	S	S	S
	Woodland carbon stores	S	S	S	S
	GHG emissions (top 10%)	S	S	S	S
Flood risk	High flood risk (SPR>40%) in uplands	S	S	S	n.a.
	Floodplains; Ramsar Sites; Flood Risk Zones	S	S	S	S
	Managed retreats	n.a.	n.a.	n.a.	n.a.
Farm historic environment	Scheduled monuments & listed buildings	(S)	(S)	(S)	(S)
Soil quality	Soil erosion risk >2t/ha/yr; arable SOC<2%	S	S	S	S
Water quantity	Agricultural demand >100% available	S	S	S	S
Resource protection	Soil Erosion risk >2t/ha/yr, WFD at risk catchments; sediment loading	S	S	S	S
	WFD at risk catchments; Nutrient load	S	S	S	S
	WFD at risk catchments; Manure load (top 10%)	S	S	S	S
Public access	New public access (targets)	N*	N*	N*	N*

S = Spatial data available

N = Numerical data only (N* = data estimated)

n.a. = No data available

4. Coverage

The area associated with each policy sub-objective is defined by the selected indicators (and related dataset). Table 4 sets out the area (or length) for each indicator by country and for the UK in total. For some indicators, the data is based on the current inventory e.g. BAP priority habitats / species while for others, data represents the 2020 target, annualised over the period e.g. woodland creation, water storage reservoirs.

Table 4: Coverage of indicators by country

Indicators	Unit	England	Scotland	Wales	N. Ireland	UK
Blanket Bog	ha	255,308	1,759,000	34,499	139,796	**2,188,603**
Cereal field margins	ha	98,457	1,661	2,663	2,436	**105,217**
Coastal & Floodplain Grazing Marsh	ha	239,632	1,500	54,600	4,782	**300,514**
Hedgerows	m	547,000,000	46,000,000	106,000,000	118,612,000	**817,612,000**
Lowland Grassland	ha	66,111	6,118	38,941	1,611	**112,781**
Lowland Heathland	ha	58,000	18,888	12,500	5,778	**95,166**
Lowland Raised Bogs	ha	17,411	13,000	1,830	21,106	**53,347**
Lowland wood pasture & parkland	ha	22,000	12,500	7,000	1,100	**42,600**
Purple moor grass & rush pasture	ha	21,544	6,768	32,161	18,476	**78,949**
SSSIs (ASSIs in N Ireland)	ha	727,165	892,639	91,757	87,806	**1,799,367**
Upland Grassland	ha	13,163	5,027	700	936	**19,826**
Upland Heathland	ha	243,929	778,000	80,000	11,059	**1,112,988**
Wet woodland	ha	20,000	21,713	12,200	2,600	**56,513**
Woodland	ha	1,292,646	1,096,711	322,706	66,864	**2,778,927**
Arable assemblages	ha	1,446,165	569,536	89,447	50,417	**2,155,565**
Grassland assemblages	ha	1,503,111	468,089	46,410	37,479	**2,055,089**
3km connectivity buffer	ha	4,327,162	827,251	151,964	231,947	**5,538,324**
Woodland creation (targets)*	ha	2,000	3,500	200	500	**6,200**
Landscape designations	ha	2,583,778	691,590	528,945	166,063	**3,970,376**
Stone walls	m	81,500,000	78,580,000	13,470,000	7,790,000	**181,340,000**
Energy crop plantings (targets)**	ha	60,900	30,000	45,000	10,000	**145,900**
Peat carbon stores	ha	400,448	1,969,029	54,217	245,236	**2,688,930**
GHG emissions (top 10%)	ha	3,608,279	386,833	594,415	603,048	**5,192,575**
Flood risk - uplands	ha	11,457	43,296	20,129	3,557	**78,439**
Flood risk - water storage	ha	1,351,610	346,994	97,695	144,245	**1,940,544**
Managed retreats***	ha					
Historic sites	ha	36,357	10,096	3,343	8,697	**58,493**
High risk agricultural soil	ha	1,999,625	395,545	7,617	12,758	**2,415,545**
Agricultural demand >100% of available water****	m^3	3,472,680	-	-	-	**3,472,680**
Soil Erosion risk >2t/ha/yr	ha	401,900	289,200	4,500	14,000	**709,600**
Diffuse/ agricultural pollution	ha	5,371,490	414,241	712,241	453,634	**6,951,606**
Manures loading (top 10%)	ha	1,150,154	455,000	348,545	139,663	**2,093,362**
Public access	km	190,000	70,000	33,238	1,000	**294,238**

* Based on Forestry Commission data for 2008-09 http://www.forestry.gov.uk/pdf/area09.pdf/$file/area09.pdf and published targets for N Ireland http://www.forestserviceni.gov.uk/strategy-for-sustainability-growth.pdf

** Based on published targets

*** There is no nationally held spatial data on the locations of managed retreats. Shoreline Management Plans (SMPs) may be a source of local data.

**** Based on current deficit (England only) plus 20% predicted growth by 2020 (annualised)

4.1 Overlaps

The analysis of overlaps relied on using spatial data (where available) to overlay indicators in turn to determine whether or not they overlap. All pairwise combinations of indicators were considered, and the area of overlap calculated for each. The absolute level of overlaps is further considered in terms of coverage by AES. Where there was no or negligible overlap, then management options that apply to these indicators are discrete and no further analysis was required. Where indicators overlapped spatially, the indicator areas were adjusted according to which of the following three situations apply:

(i) AES options to address indicators are different but complementary (*'distinct options'*) - the area of overlap was counted under both objectives and no further analysis was required.

(ii) AES options to address indicators are the same or similar enough for them to be addressed by a single prescription ('*combined options'*) - the area of overlap was counted for the combined option and subtracted from the other indicator areas to avoid double counting.

(iii) AES options to address indicators are conflicting (*'incompatible options'*), only one option was considered for the overlapping area. In this case, the area of overlap was subtracted from the other indicator area.

Identification of areas where more than two indicators overlap was accounted for using spatial analysis tools as set out in Appendix 4. Where spatial data were missing for a particular country (i.e. BAP Priority Habitats for Scotland and N Ireland), the combined Priority Habitat / non-Priority Habitat indicator overlap for England as a proportion of the total non-PH indicator area was applied to the total non-Priority Habitat indicator area for the other country.

Table 5 sets out the revised coverage data for indicators after adjustment for overlaps. The analysis suggests that due to a lack of complementarity or conflict between scheme options in overlap areas, the net reductions in coverage due to overlaps is not too significant for most indicators. The exceptions are:

- Flood risk (uplands) – this is a very broad indicator and in practice the policy objective would be delivered through small scale planting of trees in highly targeted areas (coverage was initially set at 10% of the area). As such, the reduction of the area due to overlaps does not threaten achievement of the objective but the coverage estimate has been doubled to 20% for costing purposes (to offset the 42% reduction in area from overlaps).

- Soil Erosion risk >2t/ha/yr – this is a highly targeted area and it is virtually lost due to overlaps (the difference from 100% is due to rounding errors). The main contributing factor is overlap with the high risk agricultural soils indicator, which uses the same soil erosion indicator and similar interventions (Table 6). As such the policy objective would still be met.

- Diffuse/ agricultural pollution – again this is a very broad indicator and coverage was initially set at 25% of the area for costing purposes; this has been doubled to 50% to allow for the high overlap reduction in area (32%).

- Manures loading (top 10%) – again this is a broad indicator and extensive area; it is unlikely that the policy objective will be threatened by the reduction in area as the contributing indicators which overlap (Table 7) have a similar focus (notably at risk WFD catchments) and interventions (buffer strips).

Table 5: Coverage of indicators at UK level after allowing for overlaps

Indicators	Unit	Gross units	Units adj. for overlaps	Change in area (%)
Blanket Bog	ha	2,188,603	2,188,603	-
Cereal field margins	ha	105,217	105,217	-
Coastal & Floodplain Grazing marsh	ha	300,514	300,514	-
Hedgerows	m	817,612,000	817,612,000	-
Lowland Grassland	ha	112,781	112,781	-
Lowland Heathland	ha	95,166	95,166	-
Lowland Raised Bogs	ha	53,347	53,347	-
Lowland wood pasture & parkland	ha	42,600	42,600	-
Purple moor grass and rush-pasture	ha	78,949	78,949	-
SSSIs (ASSIs in N Ireland)	ha	1,799,367	1,799,367	-
Upland Grassland	ha	19,826	19,826	-
Upland Heathland	ha	1,112,988	1,112,988	-
Wet woodland	ha	56,513	56,513	-
Woodland	ha	2,778,927	2,243,864	-19%
Arable assemblages	ha	2,155,565	2,041,546	-5%
Grassland assemblages	ha	2,055,089	1,896,975	-8%
3km buffer around habitats / assemblages	ha	5,538,324	5,178,076	-7%
Woodland creation (targets)	ha	6,200	6,200	-
Landscape designations	ha	3,970,376	3,876,865	-2%
Stone walls	m	181,340,000	181,340,000	-
Energy crop plantings (targets)	ha	145,900	145,900	-
Peat carbon stores	ha	2,668,930	2,364,696	-11%
GHG emissions (top 10%)	ha	5,192,575	4,784,572	-8%
Flood risk - uplands	ha	78,439	45,652	-42%
Flood risk - water storage	ha	1,940,544	1,624,996	-16%
Managed retreats	ha	-	-	-
Historic sites	ha	58,493	58,493	-
High risk agricultural soil	ha	2,415,545	2,279,159	-6%
Agric demand >100% of available water	ha	3,472,680	3,472,680	-
Soil Erosion risk >2t/ha/yr	ha	709,600	21,521	-97%
Diffuse/ agricultural pollution	ha	6,951,606	4,739,434	-32%
Manures loading (top 10%)	ha	2,093,362	649,928	-69%
Public access	m	294,238,000	294,238,000	-

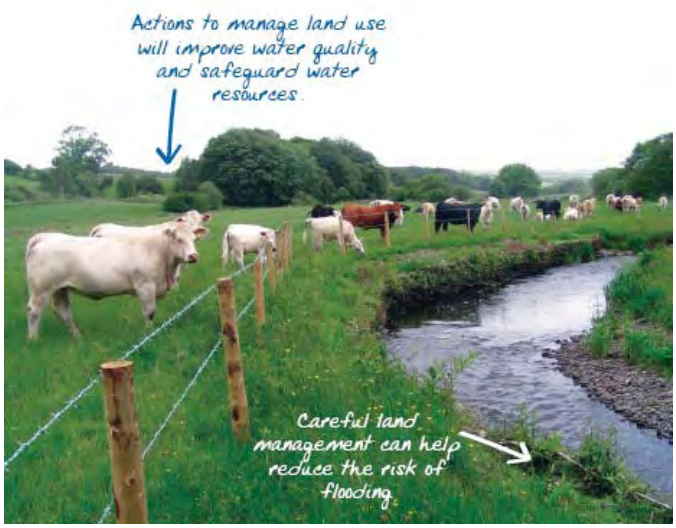
Table 6: Contributing indicators for overlap reductions in soil erosion risk area

Indicators	England	Scotland	Wales	N. Ireland
High Risk Ag Soil	95%	96%	99%	99%
Flood risk - Water Storage	8%	5%	9%	21%

Table 7: Contributing indicators for overlap reductions in manures loading area

Indicators	England	Scotland	Wales	N. Ireland
Grassland Assemblage	21%	11 %	2%	3%
Greenhouse Gases (top 10%)	64%	35%	76%	85%
Diffuse/ Agricultural Pollution	61%	18%	50%	51%

The extent to which a single AES option can address more than one indicator represents added value through the delivery of multiple benefits. This raises a question over whether the policy objectives are being met through an intervention for a separate indicator e.g. 'reducing sediment loading due to run-off and soil erosion' might be met through other interventions which focus on arable reversion or buffer strips. There are many instances of multiple outputs from single actions, highlighting the scope for policy efficiency.



Source: EA Water Resources Strategy for England and Wales http://publications.environment-agency.gov.uk/pdf/GEHO0309BPKX-E-E.pdf

The recently published EA Water Resources Strategy emphasises the need for intervention at a catchment scale to address water quantity and quality issues. The strategy also highlights the role of land use change and management on water resource management, and links to biodiversity (water-dependent nature conservation sites) and flood risk mitigation. It also recognises the role of financial incentives and advice for land managers to deliver improved water quality and resources.

Figure 2 and Figure 3 show the extent of overlap between individual indicators. The maps illustrate a significant extent of overlap, notably for biodiversity but also for climate change and resource protection indicators. Note that the biodiversity overlaps are generally reflected in reductions in the indicator area for other objectives, as discussed earlier. Thus if all the resource protection indicator area were counted as such, the area (and cost) would increase significantly at the expense of biodiversity, flood risk and climate change numbers. The same analysis applies to climate change indicator area which overlaps with resource protection and biodiversity. In both cases, the overlap area counted as biodiversity and biodiversity options have been applied. While this does not impact significantly on the cost estimates, AES biodiversity options are generally higher cost (£100-200 per ha) than resource protection or climate change (£50-150 per ha).

Table 8 summarises the extent of coverage of indicators across the four countries by broad policy objective (biodiversity, climate change, flood risk and resource protection). It highlights the extensive coverage for biodiversity (22-43% of land area) and climate change (26-53% of land area) across all countries. For resource protection, the picture is more varied, ranging from 12.5% of land area in Scotland to 39.6% of land area in England, reflecting large areas of extensive land use in the former. For flood risk, the land area across countries is more modest at 6-10%.

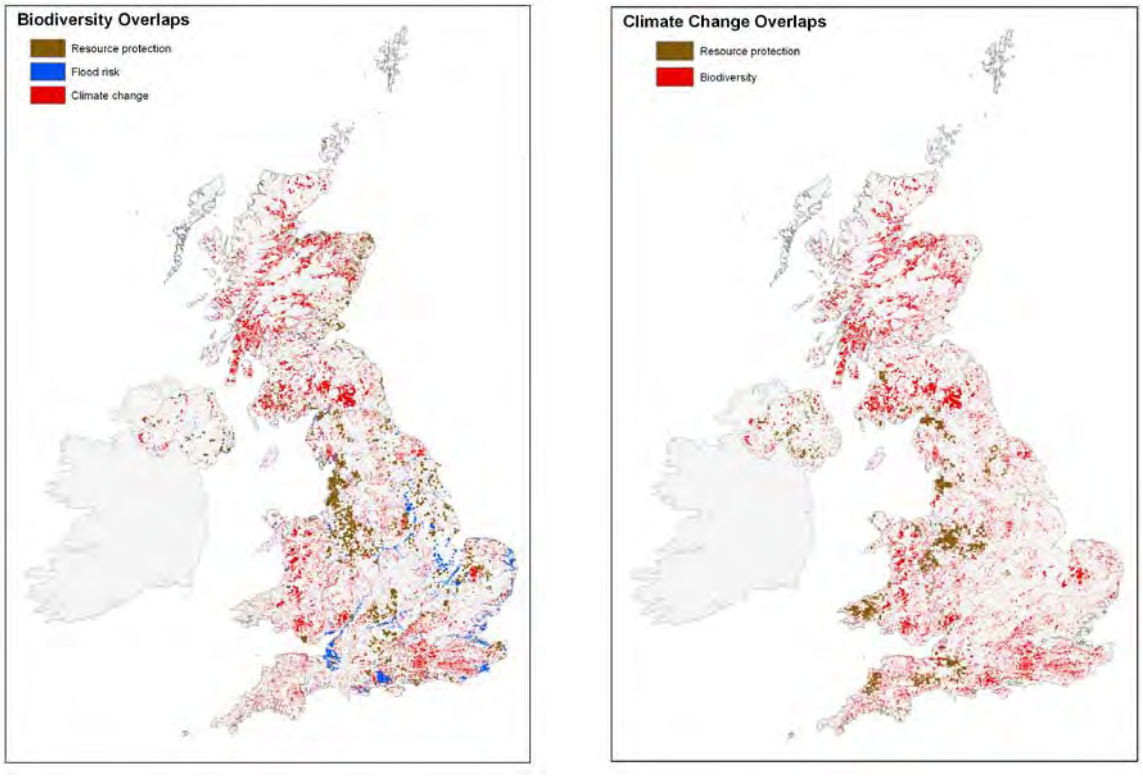


Figure 2: Extent of overlaps between indicators – biodiversity and climate change

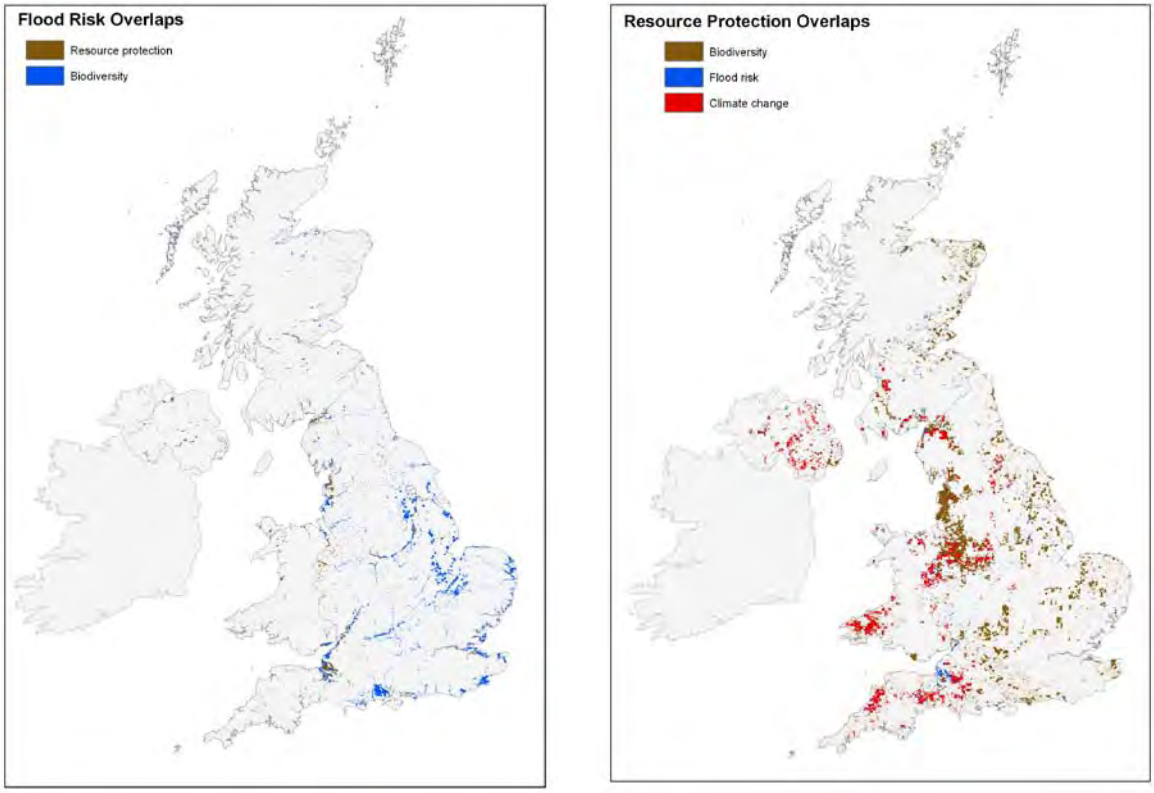


Figure 3: Extent of overlaps between indicators – flood risk and resource protection

Table 8: Coverage of policy objectives and extent of overlap met by a single AES option

Country	Total area (ha)		Biodiversity	Climate Change	Flood risk	Resource Protection
England	13,056,426	Indicator area (ha)	4,286,511	5,064,521	1,362,167	5,163,582
		% Country	32.8	38.8	10.4	39.6
		Single AES overlap* (ha)	247,695	247,646	486,922	1,984,895
		% Overlap AES single	5.8	4.9	35.8	38.4
Scotland	7,933,431	Indicator area (ha)	3,386,499	2,040,861	388,115	989,937
		% Country	42.7	25.7	4.9	12.5
		Single AES overlap* (ha)	27,751	17,602	32,034	474,102
		% Overlap AES single	0.8	0.8	8.3	47.9
Wales	2,075,050	Indicator area (ha)	453,809	907,452	117,520	666,663
		% Country	21.9	43.7	5.7	32.1
		Single AES overlap* (ha)	8,943	61,027	13,789	334,957
		% Overlap AES single	2.0	6.7	11.7	50.2
N Ireland	1,416,883	Indicator area (ha)	460,507	753,244	147,659	530,754
		% Country	32.5	53.2	10.4	37.5
		Single AES overlap* (ha)	3,515	128,280	8,921	177,997
		% Overlap AES single	0.8	17.0	6.0	33.5

* Overlap with indicators allowing a combined management option

Overlaps between indicators are most significant for resource protection across all countries (34-50% of indicator area) but the overlap area is also significant for flood risk in England (35.8% of indicator area) and for climate change in N Ireland (17.0% of indicator area). This reflects the particular combination and spatial distribution of indicators but also highlights the scope for efficiency in delivery of the policy objectives through single AES options targeted at multiple objectives.

The issue of delivering objectives through an AES option which relates to other objectives is highlighted in Figure 4. This highlights the extensive use of other options to meet resource protection objectives in particular.

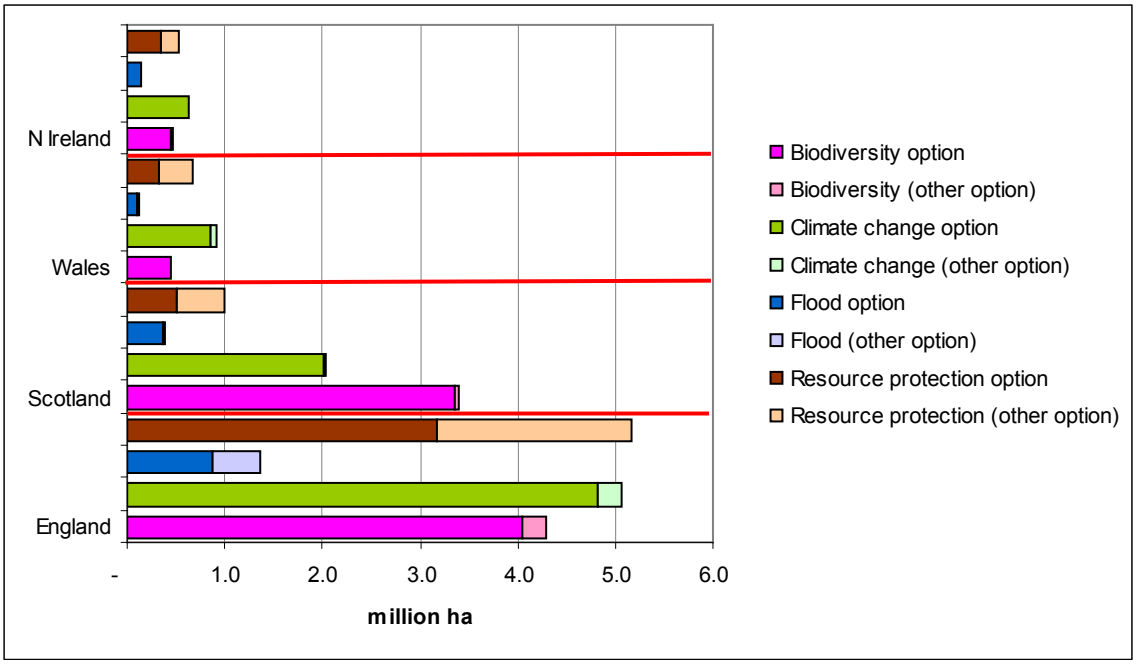


Figure 4: Extent of indicator area for key objectives and how they are met

5. Environmental scheme management options

The environmental land management required to deliver the policy (sub) objectives dictates which scheme options need to be targeted at them. Table 9 sets out the key management changes (prescriptions) required to deliver the objectives.

Table 9: Management changes by sub-objective

Sub-objective	Prescription outline
BAP Priority habitats (agricultural, farm woodland and non-farm woodland)	Maintenance or improvement of condition to achieve favourable conservation status of designated SSSIs and BAP Priority habitats
BAP Priority species (farmland and woodland)	Provision of nesting/feeding/cover for species in assemblages to achieve relevant BAP targets
Biodiversity-landscape permeability/connectivity	Land management for biodiversity or creation of green infrastructure in areas of high biodiversity value or where there are significant gaps
Biodiversity-woodland creation	Tree planting to meet published targets
Landscape-maintaining landscape character and quality	Supplement to encourage maintenance or improvement of existing character through active management of existing features
Climate change mitigation - carbon stores	Maintenance or improvement of condition of peat, wetlands, woodlands and avoidance of erosion of vulnerable soils
Climate change mitigation - carbon sequestration	Planting of energy crops to meet targets
Climate change mitigation-GHG reduction	Generic actions to reduce GHG through improving animal productivity, efficiency of use of fertiliser and storage/use of manures (beyond regulatory requirements)
Flood risk management-reducing run-off from upland catchments	Grassland - planting trees, grip blocking
Flood risk management-water storage capacity in the lowlands	Arable land - reversion to grassland Grassland - creation of wetlands and marshes through no longer maintaining existing flood defences.
Flood risk management-retreat on eroding coastlines/inland	Arable land - reversion to grassland Grassland - creation of wetlands and marshes through stopping defences.
Farmland historic environment-protection of scheduled and undesignated sites	Maintenance or improvement of condition through active management
Soil quality-organic matter / carbon	Avoidance of soil erosion and soil organic matter loss through arable reversion or use of buffer strips / winter cover crops
Water quantity-sustainable management and efficiency	Rainwater harvesting in water shortage areas
Resource protection - reducing sediment loading	Avoidance of pollution (fertilisers & chemicals) through use of barriers (buffer strips / beetle banks) and winter cover crops
Resource protection - reducing diffusion pollution	Avoidance of pollution (fertilisers & chemicals) through use of barriers (buffer strips / beetle banks) and winter cover crops
Resource protection - reducing pollution from livestock	Effective grazing management and fencing off streams
Public access-providing permissive access routes	Creation of new access (footpaths) to meet targets

Each of the four UK countries operates a separate suite of agri-environment schemes, aimed at incentivising farmers and land owners to adopt land use practices which deliver environmental policy objectives. As much of the management is potentially reversible, an important aspect of the schemes is to educate land managers in understanding the value of managing land for environmental reasons and embedding practice.

Funding is largely through the country rural development programmes (RDP) which secure funds under Pillar 2 of the CAP and matches it from national budgets. England

and Wales operate a broad and shallow 'entry-level' scheme alongside a more targeted and 'higher-level' scheme, while Scotland and Northern Ireland operate farm-level schemes. The four country schemes are as follows:

- Environmental Stewardship (ES) in England
- Rural Development Contracts: Rural Priorities in Scotland.
- Tir Gofal, Tir Cynnal, Organic Farming Scheme and the Better Woodlands for Wales scheme in Wales[9]
- Northern Ireland Countryside Management Scheme (NICMS)

The agreed approach was to consider the range of relevant scheme options which might contribute to each policy (sub) objective and construct a 'generic' option that captures the key prescriptions necessary to deliver the objective. This process was undertaken with input from specialists from ADAS and SAC in biodiversity, landscape and resource protection. The output was a list of generic scheme options (or other where appropriate) for each policy indicator (Table 10).

It should be noted that the soil conservation and resource protection were introduced as one of the five primary objectives in ES in England at the launch of the scheme in 2005. These had not previously been specific objectives of AES in England and this is reflected in the scope (grass buffer strips and arable reversion represent 89% of land area coverage under this objective) and uptake (251,943 ha) of current portfolio of AES options are limited[10]. The Water Framework Directive (WFD) is a priority in the SRDP but again key measures are around construction of farm wetlands, biobeds and arable reversion to grass. However, there are good potential AES measures that could be available by 2013, including rural suds measures, use of vegetated (wooded) buffer strips or ditch management / in-channel measures.

For the purposes of this research, we have limited the costing of the objectives to existing specified (and costed) measures. While this may understate the scope for delivering the objective effectively under the guise of soil conservation or resource protection, the objective is covered and as such includes an indicative cost.

Perhaps more significant is the fact that where soil conservation or resource protection indicator areas coincide with biodiversity objectives, they have been counted under the latter. The effect is to weight the allocation of costs to biodiversity at the expense of resource protection. This issue is highlighted and discussed in the text.

5.1 Scheme option costs

Payment rates to land owners for the environmental benefits delivered through agri-environment scheme options are based on income foregone, rather than the value of the public benefits *per se*. As such, the rates vary across countries according to the definition of the scheme option, the methodology used to define income forgone and the relative returns from agricultural production in each country. Given this variation, a single 'generic' AES option has been created for each policy objective using a scheme cost which reflects the range of current payment rates for relevant options. This does not allow for fundamental differences between farming systems across countries and the costings may hide opportunities for cost saving or higher costs at country level.

[9] From 2012, existing agri-environment schemes in Wales will be replaced by just one scheme (Glastir)
[10] http://www.naturalengland.org.uk/ourwork/farming/funding/aesiereport.aspx

There are a number of key assumptions:

- 'maintenance and management' options represent continued management of existing habitats to get sites into favourable conservation status and/or pay for continuing management to help keep sites at that status. Hence these costs do allow/require improvement as well as maintenance. Costs do not allow for capital items which may be associated with management e.g. fencing costs for resource protection; this could add significantly to annual costs in practice.

- 'creation' options assume new habitat/resource creation and are capital-based; the costings are based on the average annual capital cost over the lifetime of the asset. A 50% grant rate is assumed for capital investment in items such as reservoir construction, fencing along streams etc.

- 'whole farm' payments represent an annual payment to land managers in order to undertake a range of (unspecified) actions associated with, for example, landscape, biodiversity or climate change across the holding e.g. 'Rural Development Contracts: Land Managers Options' in Scotland. It is assumed that in practice these would be combined with a number of specific payments for discrete actions (hedgerow management, buffer strips etc.) as relevant in a farm-level agreement.

- other payments are very specific, for example, moorland wetting or 6 m buffer strips and are based on specific AES options rather than generic options (no cost range shown).

Table 10 sets out the range in costs for selected scheme options and that used for the generic scheme (process and costings detailed at Appendix 5 and 6).

Costs presented are based on the latest published scheme literature for each country but the income forgone calculations are historic. As such they may not represent a realistic set of costs for the policy scenario in 2020 after CAP reform. However, in the absence of such data, they represent a useful guide. This study has not looked at the actual level of costs under a reformed CAP but the preceding ADAS/SAC study for Defra (ADAS *et al* 2008) did provide some steer on this as follows (Scenario D represents full CAP reform):

'… *lower prices associated with the removal of trade barriers, reduces the opportunity cost of putting land in a stewardship scheme. Consequently, Income Forgone (and associated points) falls (by 1.2% and 4.5% for SDA and non-SDA agreements under scenario D). For HLS, the impact of the policy scenarios on the payment rates for individual options varies widely but generally there is a reduction in the cost of schemes to Government under policy scenario D.*'

In practice, some costs may also increase under a fully reformed CAP. In view of these uncertainties and assumptions around the choice of a generic AES option and the associated costs, the overall costing exercise should be seen as indicative.

Table 10: Generic scheme option costs

Indicator	Generic scheme	Scheme option cost range	Scheme option cost
Blanket Bog	Maintenance and management	£25-£40/ha	£35/ha
Cereal field margins*	Maintenance of rough grass margin / cultivated fallow margin / unfertilised cereal headland	£300-£600/ha	£450/ha
Coastal & Floodplain Grazing marsh	Maintenance and management	£60-£140/ha	£100/ha
Hedgerows	Maintenance and management	£1-£2/m	£1.50/m
Lowland Grassland	Maintenance and management	£150-£250/ha	£200/ha
Lowland Heathland	Maintenance and management	£100-£200/ha	£150/ha
Lowland Raised Bogs	Maintenance and management	£30-£50	£40/ha
Lowland wood pasture & parkland	Maintenance and management	£50-£150/ha	£100/ha
Purple moor grass and rush-pasture	Maintenance and management	£20-£50/ha	£35/ha
SSSIs (ASSIs in N Ireland) **	Whole farm payment		£10/ha
Upland Grassland	Maintenance and management	£150-£250	£200/ha
Upland Heathland	Maintenance and management	£20-£50/ha	£35/ha
Wet woodland	Maintenance and management	£50-£150/ha	£100/ha
Woodland	Maintenance and management	£100-£250/ha	£150/ha
Arable assemblages	Provision of habitats (hedgerow, field margin and headland, winter stubble and wild bird cover crop)		£200/ha
Grassland assemblages	Provision of habitats (managed open grassland and appropriate stocking densities during breeding and winter seasons)		£150/ha
3km buffer around habitats/ assemblages	Sympathetic management options around habitats / assemblages		£50/ha
Woodland creation	Woodland planting		£3,000/ha
Landscape designations**	Whole farm payment		£10/ha
Stone walls	Stone wall restoration	£16.00-£22.50/m	£20/m
Energy crop planting targets	Energy crop planting		£50/ha
Peat carbon stores	Moorland rewetting supplement		£10/ha
GHG emissions (top 10%)	Generic actions to reduce GHG		£50/ha
Agricultural areas in uplands	Creation of woodland in the SDA		£3,000/ha
Flood risk water storage	Management of Flood Plains		£40/ha
Managed retreats	Maintenance and management	£60-£140/ha	£100/ha
Historic sites	Protection of scheduled monuments and historic sites	£16-£600/ha	£250/ha
High risk ag soil	Arable reversion to grassland		£250/ha
Agricultural demand >100% of available water***	Rainwater harvesting		£20/ha
Soil Erosion risk >2t/ha/yr	Arable reversion to grassland	£50-£250/ha	£150/ha
Catchments at risk from diffuse / agricultural pollution	6 m buffer strips and cover crops		£50/ha
Manures loading (top 10%)	6 m buffer strips, fencing off streams and managed grazing		£50/ha
Public access targets	New footpaths, bridle paths and cycle paths (infrastructure)		£20/m

* Relates to the area of buffer strip, adjusted to overall field area using a coverage figure of 8% for a 6 m buffer

** Nominal - based on the England ELS payment rate of £30 per ha per year, reduced to allow for overlap with other discrete indicators such as hedgerow management, stone walls etc.

*** Based on reservoir storage of 1,000m^3 of capacity for each hectare of land under high value crops (1 year in 5) and an asset life of 25 years; a grant rate 50% is assumed on a reservoir cost of £5 per m^3

6. Policy costs

Coverage and intensity are brought together to provide a set of cost estimates, by policy objective and by country. Table 11 sets out the cost of delivering policy sub-objectives, based on the selected indicator area and scheme option and allows for spatial overlaps in indicators which can be met with a single AES option.

Table 11: Cost of delivering policy objectives (£m per year)

Indicators	England	Scotland	Wales	N. Ireland	UK	% total
Blanket Bog	8.9	61.6	1.2	4.9	**77**	4%
Cereal field margins	44.3	0.7	1.2	1.1	**47**	2%
Coastal & Floodplain Grazing marsh	24.0	0.2	5.5	0.5	**30**	2%
Hedgerows	139.5	11.7	27.0	30.2	**209**	10%
Lowland Grassland	13.2	1.2	7.8	0.3	**23**	1%
Lowland Heathland	8.7	2.8	1.9	0.9	**14**	1%
Lowland Raised Bogs	0.7	0.5	0.1	0.8	**2**	0%
Lowland wood pasture & parkland	2.2	1.3	0.7	0.1	**4**	0%
Purple moor grass & rush pasture	0.8	0.2	1.1	0.6	**3**	0%
SSSIs (ASSIs in N Ireland)	7.3	8.9	0.9	0.9	**18**	1%
Upland Grassland	2.6	1.0	0.1	0.2	**4**	0%
Upland Heathland	8.5	27.2	2.8	0.4	**39**	2%
Wet woodland	2.0	2.2	1.2	0.3	**6**	0%
Woodland	13.6	14.5	4.6	0.9	**34**	2%
Arable assemblages	136.9	53.9	8.6	4.8	**204**	10%
Grassland assemblages	104.0	32.4	3.2	2.6	**142**	7%
3km buffer around habitats / assemblages	101.1	19.3	3.4	5.7	**130**	7%
Woodland creation (targets)	6.0	10.5	0.6	1.5	**19**	1%
Landscape designations	25.8	6.9	5.3	0.7	**39**	2%
Stone walls	81.5	78.6	13.5	7.8	**181**	9%
Energy crop plantings (targets)	3.0	1.5	2.3	0.5	**7**	0%
Peat carbon stores	3.1	18.0	0.5	2.1	**24**	1%
GHG emissions (top 10%)	166.7	17.9	26.0	28.7	**239**	12%
Flood risk - uplands	1.4	14.2	10.5	1.4	**27**	1%
Flood risk - water storage	41.9	13.7	3.7	5.7	**65**	3%
Managed retreats*						
Historic sites	9.1	2.5	0.8	2.2	**15**	1%
High risk agricultural soil	94.6	18.4	0.3	0.6	**114**	6%
Agricultural water demand >100%	69.5	**	**	**	**70**	3%
Soil Erosion risk >2t/ha/yr	1.5	1.7	n.s.	n.s.	**3**	0%
Diffuse/ agricultural pollution	87.5	4.6	16.4	10.0	**119**	6%
Manures loading (top 10%)	10.2	12.6	6.8	2.9	**33**	2%
Public access	38.0	3.5	6.6	0.2	**48**	2%
Total	**1,258**	**444**	**165**	**119**	**1,986**	
% of UK total cost	63%	22%	8%	6%		
Cost per hectare of total land area (£/ha)	96	56	79	84		

* Unable to estimate – data not provided

** Indicator currently only applies to England but may extend to other regions by 2020 due to climate change; additionally actions may be given priority in terms of resource efficiency

n.s. Data is >0 but not significant

In terms of individual policy objectives, biodiversity represents the largest component at UK level at just over £1 billion or half of the total cost (Figure 5); climate change and landscape are the next most significant cost areas at 14% and 11% respectively. England represents the majority of costs by country at £1,258 million per anum (63% of the UK total) (Figure 6) and has the highest country cost per total land area.

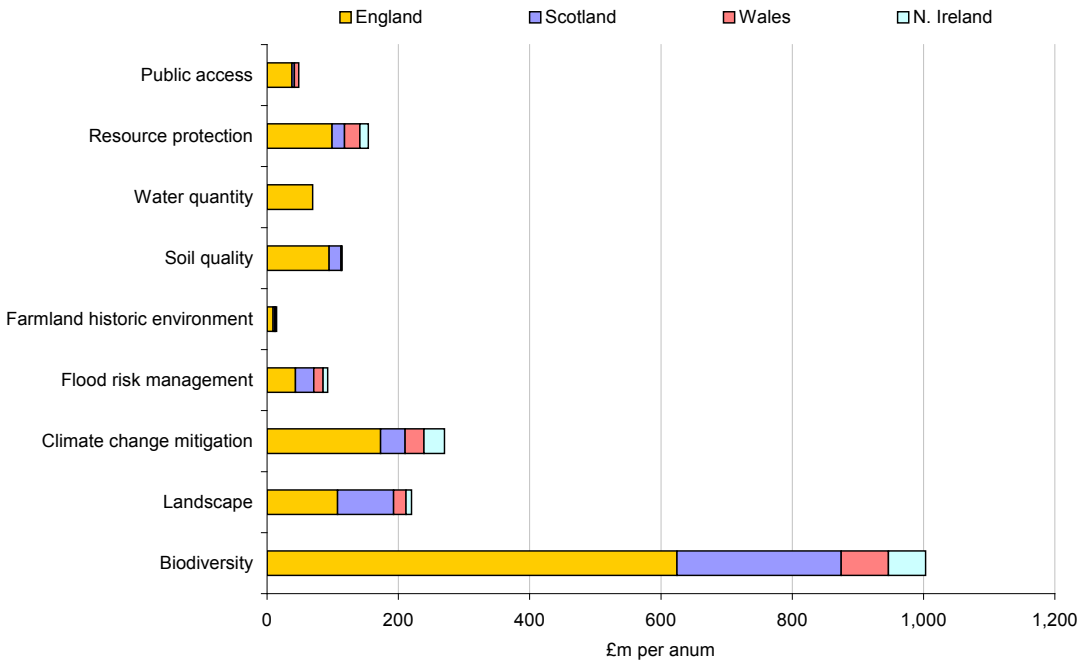
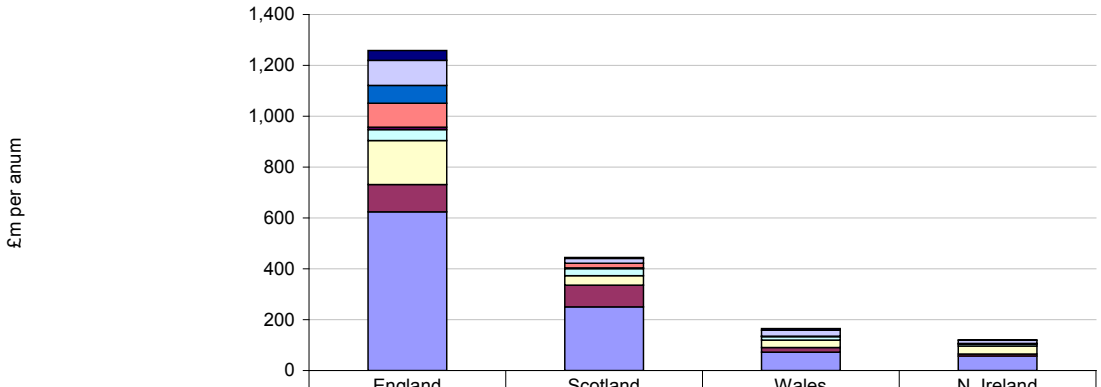


Figure 5: Distribution of environmental policy costs by objective



	England	Scotland	Wales	N. Ireland
Public access	38.0	3.5	6.6	0.2
Resource protection	99.1	18.9	23.2	12.9
Water quantity	69.5	0.0	0.0	0.0
Soil quality	94.6	18.4	0.3	0.6
Farmland historic environment	9.1	2.5	0.8	2.2
Flood risk management	43.2	27.9	14.2	7.1
Climate change mitigation	172.9	37.3	28.7	31.3
Landscape	107.3	85.5	18.8	8.5
Biodiversity	624.4	250.2	71.9	56.7

Figure 6: Distribution of environmental policy costs by country

While a discrete cost was estimated for each AES option in order to allow aggregation of costs across policy objectives and across countries, it is recognised that the range of costs of component options is substantial, generally +/- 50%. Applying this to the cost estimate gives a range for the estimated cost of future land management requirements at UK level of £1 – 3 billion. Much more certainty about the causal link between management input and environmental output is needed and further research into the scope for delivering multiple objectives from single AES schemes.

The costs shown in this report are also sensitive to a number of other assumptions, as follows:

(i) A defined set of land management policy objectives, based on existing environmental targets.

(ii) An assumption that incentives (such as agri-environment schemes) will be the primary delivery mechanism. There has been no attempt to test interventions to see if they could be delivered more effectively by other mechanisms such as regulation. The approach also assumes that sufficient scheme uptake will be secured.

(iii) Existing income forgone calculations, which are the basis of current agri-environment payments, have been used to calculate land management costs. Average costs have been used and these mask significant variations in payment rates between UK countries, in turn reflecting different farm structures, systems and costs.

(iv) No attempt has been made to adjust the income forgone calculations to reflect anticipated production costs/margins in a future scenario with a reformed CAP (no Pillar I).

(v) No account has been taken of the additional capital works costs (such as fencing) that may be required for the implementation of certain environmental management requirements.

(vi) For some policy objectives, for example resource protection and climate change adaptation and mitigation, the range of existing agri-environment scheme options (with cost data) is limited and don't necessarily reflect the management that might be required. For example, annual payments for maintenance of Upland Heath of £35/ha will only pay for adjusting grazing levels, not grip blocking/raising of water levels so as to restore biodiversity, improve water quality and secure existing carbon stores.

(vii) The lack of availability of suitable spatial data in individual countries has required that the indicators selected for some policy objectives are not mapped accurately, with consequent inaccuracies in overlaps and costs.

7. Conclusions

The research objective for this study was to estimate the cost of delivering environmental policy objects across the UK under a reformed CAP. This has involved two distinct phases on work: The first focused on selection of appropriate indicators for each policy objective, quantifying and mapping them (where possible) and dealing with overlaps; the second assigned AES options to each indicator (and overlap) along with a unit cost. Finally the two phases were brought together to estimate the cost by policy objective and by country as well as a total cost for the UK.

Table 12 sets out the extent of coverage of total land area across the UK countries (allowing for overlaps) and the proportion that is not covered. There is uncertainty as to whether some of the policy objectives have been fully covered, notably in Scotland. However, much of the area with no indicator is outside agriculture and forestry and as such not considered in this research.

Table 12: Extent of coverage and overlaps across countries

Indicators	England	Scotland	Wales	N. Ireland
Total land area (ha)	13,056,426	7,933,431	2,075,050	1,416,883
Total indicator area* (ha)	11,144,227	4,443,615	1,538,813	1,108,670
% Indicator	85%	56%	74%	78%
% No indicator	15%	44%	26%	22%
Total agriculture & forestry (ha)	10,439,180	3,310,536	1,359,787	1,047,399

* While some datasets were confined to agriculture and forestry, others included land outside this definition; consequently the indicator area is greater than the total land in agriculture and forestry across all 4 countries.

In terms of broad policy areas, biodiversity and climate change coverage is significant across all countries (22-53% of land area). For resource protection, the picture is more varied, ranging from 12.5% of land area in Scotland to 39.6% of land area in England, reflecting large areas of extensive land use in the former. In terms of flood risk, the land area is more modest across all countries at 6-10%.

Allowing for overlaps reduces the coverage area significantly for a limited number of policy objectives, notably flood risk (uplands), soil quality and resource protection due to common indicators or closely associated indicators. As such multiple environmental objectives can be met efficiently. There is limited reduction in the biodiversity indicator areas as these have taken precedence over other indicators such as climate change, flood risk and resource protection. As such, the synergy between for example maintaining upland bogs and protecting peat as a carbon store is captured in the latter. Not all the overlaps are visible, for example, the maintenance of priority habitat woodland and woodland species assemblages which are largely coincident.

The assignment of AES options to indicators and overlap areas was a pragmatic exercise, accounting for the generic management requirements and using a unit cost which reflected the balance of relevant options. Ongoing management was regarded as an annual cost while capital items or creation of new assets such as tree planting or building water storage reservoirs were costed and annualised over the lifetime of the asset. Where management input is periodic e.g. restoration of hedgerows or managing woodlands for biodiversity, the coverage has been scaled back to reflect this. On this basis, costs have been estimated for all policy objectives across the four countries (see Table 13). The use of generic AES options across the countries does not allow for any variation in scheme costs which may exist, notably lower costs where systems are inherently more extensive.

Table 13: Current RDP and estimated average annual spend on environmental objectives

	England	Scotland	Wales	N. Ireland	UK	% Total
Biodiversity	624.4	250.2	71.9	56.7	**1,003**	51%
Landscape	107.3	85.5	18.8	8.5	**220**	11%
Climate change mitigation	172.9	37.3	28.7	31.3	**270**	14%
Flood risk management	43.2	27.9	14.2	7.1	**92**	5%
Farmland historic environment	9.1	2.5	0.8	2.2	**15**	1%
Soil quality	94.6	18.4	0.3	0.6	**114**	6%
Water quantity	69.5	0.0	0.0	0.0	**69**	3%
Resource protection	99.1	18.9	23.2	12.9	**154**	8%
Public access	38.0	3.5	6.6	0.2	**48**	2%
Estimated spend on Pillar II, Axis 2	**1,258**	**444**	**165**	**119**	**1,986**	
Axis 2 budget (RDP 2007-2013)	469	161	85	27	742	
% increase on av. 2007-2013 Axis 2 spend	168%	176%	94%	341%	268%	

The analysis indicates a total cost of meeting future land management requirements at UK level of £2 billion per year and a range of £1-3 billion due to variation in the cost of AES options across countries and between the ranges of relevant mitigation options. Further research is needed into detailing the scale of management input requirements and the scope for delivering multiple objectives from single AES options. Note that the policy costs relate only to AES payments made to landowners and exclude the administration costs of policy design and management, promoting the schemes and payment/audit. This can add substantially to the overall cost of delivering the objectives. No allowance is made for encouraging and embedding behavioural change e.g. through awareness, information and advice.

Costs are based on current AES costings, land use and indicator datasets but relate to delivery of environmental objectives under a reformed CAP in 2020. Previous research suggests that while the unit cost of schemes may actually be lower under a reformed CAP (lower returns from farming are reflected in reduced income forgone from following AES prescriptions), additional funds may be needed to deal with land which is no longer farmed and increased spatial concentration of some sectors. Climate change is also likely to present some additional challenges which have not been anticipated in this study. Thus the use of current indicator areas and costings provides an indication of the cost of meeting future land management requirements and should be interpreted as such.

The main policy instrument for delivering the objectives is the AES funded under axis 2 of the country RDPs. A recent review of the effectiveness of AES for LUPG[11] concluded that '*overall, there is good evidence that UK agri-environment schemes have delivered significant benefits to biodiversity … and that they are contributing positively to the protection and enhancement of landscape quality and the maintenance of historic features including buildings, planned landscapes and monuments'*. However, issues of resource protection, climate change, flood risk and

[11] Bishop, J., Boatman, N., Dwyer, J., Gaskell, P., Jones, N., Mills, J., Parry, H., Ramwell, C and Short, C. (2008) A review of environmental benefits supplied by agri-environment schemes FST20/79/041

public access are not well addressed within RDPs. Public money is invested in advice programmes and grant schemes to deliver these objectives outside RDPs but it is not easy to capture total annual spend.

In comparison to current public expenditure on the delivery of environmental objectives, our cost estimates are high (Table 13). However, the data is not entirely comparable; the RDP focuses on delivery of biodiversity and landscape objectives and includes an element of socio-economic spend on LFAs. Nevertheless, this work suggests that a considerable additional budget is needed to deliver a comprehensive package of economic measures to fully deliver the range of environmental objectives.

Ultimately the rationale for AES spend is the value of the environmental public goods purchased through the intervention. The environmental accounts for agriculture[12] provide a framework for measuring and valuing the positive and negative impacts of agriculture on the environment. While the accounts indicate a gross benefit of £1.7 bn in terms of biodiversity and landscape, this is offset by negative externalities (water pollution, flooding, GHG emissions etc.) of £2.6 bn. AES can help secure and build on the former and limit the latter but the element of this which can be attributed to AES (additional) is difficult to measure. This relates to uncertainties around the link between management input and environmental output[13]. These considerations are beyond the scope of this research but are critical to securing environmental objectives on a value for money basis[14].

Overall, the analysis shows the scale of increase likely to be required for future Pillar 2 funding in order to meet publicly defined environmental management objectives. This represents an initial estimate of minimum requirements and additional funding may be required in the future to ensure all objectives are fully addressed. Within the UK, the scale of Pillar 1 support (comprising direct payments and market support) is currently much more significant than Pillar 2. In 2008, direct payments under the SPS totalled £2.6 billion, while AES payments were only £0.5 billion and LFA payments were £0.13 billion[15]. However, whilst the estimated AES requirement is £2 billion per year, the likely costs could range from £1-3bn. As a result the estimate represents a significant increase on the current Pillar 2 allocation but is likely to lie within the current combined SPS and Pillar 2 budgets for the UK.

[12] https://statistics.defra.gov.uk/esg/reports/envacc/UKCountryTables.xls#UK!A1

[13] Whittingham, M.J. (2007) Will agri-environment schemes deliver substantial biodiversity gain, and if not why not? Journal of Applied Ecology 44, 1-5.

[14] A joint Natural England-Defra research project is currently underway which will provide an up to date value for the non-market benefits of ES in England while an ADAS-led research project for the Welsh Assembly Government (WAG) is looking at the impact of the schemes on the environment in Wales.

[15] https://statistics.defra.gov.uk/esg/publications/auk/2008/default.asp

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Appendix 2: Project Specification

1. Forecast Industry structure

- Biodiversity
  - Favourable conservation status of designated SSSIs and Biodiversity Action Plan (BAP) targets for agricultural, farm woodland and non-farm woodland UK BAP Priority habitats;
  - Achieving relevant targets for widespread farmland and woodland BAP priority species;
  - Increasing landscape permeability/connectivity by establishing buffers/green infrastructure etc to help allow biodiversity to adapt to climate change;
  - Woodland creation to meet published targets (e.g. Northern Ireland 550ha/yr to reach 1650ha new woodland by 2011)
- Landscape
  - Maintenance of landscape character and quality, focused on areas of high existing landscape value.
- Climate change mitigation
  - Protect existing major carbon stores (peat, wetlands, woodlands, soils);
  - Carbon sequestration - provide energy crops for renewable energy (e.g. England Biomass Strategy 350, 000ha by 2010, NI 12% electricity from indigenous renewable sources by 2012)
  - Reduce carbon equivalent greenhouse gas emissions from agriculture (as per the broad targets set out in the Climate Change Act 2008):
    - CO_2
    - NH_3
    - N_2O
    - CH_4
- Flood Risk Management – increase the potential to hold water in the landscape and reduce surface run-off.
  - Adaptation to flood risks – reducing run-off from upland catchments;
  - Provision of water storage capacity in the lowlands.
  - Managed retreat on eroding coastlines/inland.
- Farmland historic environment.
  - Protection of scheduled and undesignated sites in farmland and woodland, including historic farm buildings.
- Soil Quality.
  - Build soil organic matter/carbon to protect soil quality.
- Water quantity – management and efficiency
  - Sustainable use of water resources, adoption of management practices that maximise efficient use of water in the face of climate change.
- Resource protection – achieve Water Framework Directive water quality objectives.
  - Reduce sediment loading due to run-off and soil erosion
  - Reduce diffuse nutrient pollution of water.
  - Reduce pesticide pollution of water.
  - Reduce water pollution from livestock (faecal indicator organisms)
- Management of land for public access.
  - Providing permissive access routes that help to link up the existing statutory network.
- Climate change adaptation
  - Cross-cutting – specifics subsumed into other objectives.

2. Forecast policy scenario.

- Major CAP reform which assumes complete removal of Pillar 1 domestic support: Single Payment Scheme, export tariffs and import tariffs.

- ❑ Cross-compliance requirements that currently go beyond the regulatory baseline would no longer be supported and would require funding (if identified as contributing to policy objectives)
- ❑ Agricultural restructuring along the lines forecast by the ADAS study and other similar work [16] [17] - no new modelling work is envisaged as part of this project.
- ❑ The implications of land out of agriculture/major system restructuring considered as far as possible but not reflected in the costings.
- ❑ Changes in farming systems in direct response to climate change.

The environmental impacts of this policy scenario were assessed in ADAS/SAC report on the environmental impacts of CAP reform in England (referred to as scenario D). These are summarised as follows:

Landscape: There will be measurable changes in the English landscape under all scenarios with scenario D having the most potential for negative impacts on the landscape due to the larger extent of reductions in agricultural activity occurring across most enterprises. With an estimated 15% of land going out of production under Scenario D, this could profoundly change the existing character of the landscape. The degree to which the change in character is noticeable will depend on future land use in these areas.

- Landscapes that are predicted to end up 'Neglected' or 'Diverging' from their current state (i.e. those landscapes where the original statement of intent for landscape character could be impacted by changes in agricultural practice) will require an increased focus from Pillar II schemes. This will involve measures to protect landscape features such as boundaries and support for current land management practices.

- As a result of the changes in the agricultural sector, some farming businesses may no longer be interested in environmental stewardship schemes as they move into more profitable areas of production. In time, key landscape features may be lost or depleted to a level where traditional skills in landscape management are rare. In some cases the landscape change may occur at a rate that is too fast or expensive to reverse and these landscapes will need to be re-evaluated in terms of future direction and change.

Biodiversity: All three scenarios will have impacts on biodiversity, both positive and negative. Specific management regimes are needed to meet individual site objectives for biodiversity and there is no clear indication of the net impact across protected sites.

- There will be a positive impact on SSSIs which are currently in unfavourable condition due to overgrazing, particularly those in the uplands under Scenario D. However, there is a risk that some upland areas, particularly at localised levels, may become undergrazed, negatively affecting associated SSSIs.

- The reduction in numbers of grazing livestock in predominantly arable areas will lead to further undergrazing of lowland grassland BAP habitats. Under the current HLS rules many ESA grassland areas are unlikely to qualify for HLS funding when their agreements expire; this will therefore need to be addressed if quality of lowland grass habitats is to be maintained.

[16] Potential impact of trade liberalisation in the DOHA round. SAC research report for Defra 2005.
[17] Baseline Projections for Agriculture and implications for emissions to air and water. ADAS research report for Defra 2007.

- The reduction in spring cropping and in the diversity of cropping will lead to a further decline in farmland bird numbers, as a result of a decrease in overwintered stubbles and a reduced range of food sources. Impact will be greatest under Scenario D but the likely increase in rotational fallow will mitigate this effect to a limited extent. The reduction in grazing pressure in upland areas will be beneficial to birds.

Water Quality: Under all three scenarios, livestock numbers are expected to fall, with a move towards more extensive production of cattle and sheep. This change in farming practice should cause a reduction in potential nitrate and P loading to water bodies.

- The overall reduction in arable area may also result in a reduction in nitrate and P loading. However, there will be localised variations, notably in the east, where the cropping area will remain relatively stable under all scenarios; specialist crops such as potatoes are expected to be more concentrated in some areas, potentially resulting in higher localised P loading.

- Scenario D, on the whole delivers the greatest reduction in nutrient loads, but these reductions are small. Nutrient load reductions have the potential to improve water quality.

Soil Quality: Under all reform scenarios there is a decline in livestock numbers, with a consequent reduction in soil compaction and hence the risk of soil erosion is likely to decline. In addition to the direct impact on soils of less grazing livestock, there will also be indirect impacts associated with farming practices such as manure spreading, maize cultivation and silage making. However, there may be concentration of livestock in some areas at a local scale e.g. dairying in the west, resulting in soil degradation from compaction and soil erosion.

- Under all scenarios, but D, a focus on reducing costs will encourage minimum tillage, which disturbs soil structure less and results in less soil erosion and an overall improvement in soil structure. However, localised concentration of intensive arable crops such as potatoes is likely to cause a decrease in soil stability and an increase in soil erosion.

- A reduction in spring cropping would lead to less bare ground overwinter, with associated benefits in reduced sediment leaching risk.

Greenhouse Gas and Ammonia Emissions: Total methane emissions are estimated to decline by 19% from the 2015 base year estimate for scenario D. These reductions in emissions relate to decreases in the numbers of ruminants.

- Grazing, inorganic fertiliser spreading and crop residues are the most significant direct sources of N_2O emissions, whilst N leaching is the greatest indirect N_2O source. Total N_2O losses are estimated to reduce by 18% under scenario D, compared with the baseline year estimate for 2015.

- Emissions of ammonia from English agriculture are predicted to fall by 17% under scenario D, compared with the baseline year estimate for 2015. Reductions in NH_3 emissions are due to a combination of reduction in the cropping and livestock sectors.

Flood Risk: The potential for significant impacts in terms of changes in flood risk is limited to consideration of land predicted to move out of agricultural production. Since the end use of this land is not known, it is difficult to determine what the actual change in flood risk may be. If land out of production was converted to high run-off risk uses, such as for instance developments without proper Sustainable Urban Drainage Systems (SUDS), then the run-off risk would increase. If it was converted to moderate risk land uses, then it would stay roughly the same. If the land was put into low run-off risk use, such as grassland or forests, then flood risk would be reduced.

Appendix 3: Selection of Indicators

The preferred indicators have been discussed and agreed with the LUPG steering group. Following selection of the most appropriate indicator datasets, a number of assumptions had to be made regarding the use of these data for estimating coverage and overlaps. The key assumptions, explanations and their potential effects are summarised below.

1. **Overlaps between Priority Habitats and other indicators in Scotland and Northern Ireland are similar to those in England.** Mapped priority habitat inventories were only available for England, and inferred from Phase 1 data for Wales. Estimates of overlap with other indicators therefore had to be made from the England data. This may have resulted in under or over estimates due to differences in the spatial pattern of indicators in the different countries.
2. **Bird assemblage maps target important areas for BAP priority species in all regions.** There is a lack of bird species data for Wales and Northern Ireland, either because the targeting data is not yet available, or there are fewer species to select from. This may result in a bias towards regions where more data is available or where more bird species associated with the particular habitat occur (i.e. England & Scotland).
3. **Thresholds used for gridded datasets represent the most appropriate cut-offs for the purpose of spatially targeting.** For gridded indicators (GHG emissions; soil erosion risk; organic carbon content; BAUIII data; manure loading), a cut-off value had to be selected, above which land was considered to have the greatest need for mitigation. The decision for these cut-offs was largely arbitrary in the case of GHG emissions, BAUIII diffuse pollutants and manure loading, and was selected based on the data itself (i.e. the 90th percentile). This may have resulted in under or over estimates of the requirement.
4. **Soils with erosion risk of >2t/ha/yr and/or ≤2 & OC content are the best indicators of low soil quality.** These indicators and thresholds were chosen based on published research; however there is conflicting research that suggests that a direct link cannot be inferred between organic carbon content and soil quality. It is possible that a more accurate indicator might be the type of management and crop on tilled land; however such data is not readily available at a sufficiently fine resolution on a national scale.
5. **BAUIII sediment, phosphorous and nitrate loading models are suitable surrogates for WFD 'at risk' catchments in England & Wales.** Due to licensing issues, we could not be provided with spatially referenced WFD risk assessment data for England & Wales. As a surrogate indicator, the outputs from Defra project SFF0601 were used, which modelled total loss of Z, N & P at a 10km grid scale. It is not known how similar the targeted areas are to the 'at risk' catchments, but there are likely to be differences in spatial location and extent.

The indicators are listed by policy objective, including rationale for selection, data source and limitations in tables 14-28 and mapped, where available in figures 6-14.

1. Biodiversity

(a) Favourable conservation status of designated SSSIs and Biodiversity Action Plan (BAP) targets for agricultural, farm woodland and non-farm woodland UK BAP Priority habitats

Table 14: Favourable status of designated SSSIs and BAP Priority habitats

Indicator	Rationale & methodology	Data source	Limitations
SSSIs (ASSIs in N Ireland)	Boundaries of SSSIs and ASSIs were sourced from the relevant bodies. From these, those that had agricultural interest (e.g. designated for habitats or species that could occur on agricultural land or woodland) were selected. Methodology for selection was dependent on the country and what attribute data they had available, but all excluded marine and geological designations as a starting point. The second stage was to identify features that are likely to require management under the RDP. We took a generous approach on the basis that the expectation is that all management required for SSSIs & Natura2000 should now be funded under the RDP.	England: MAGIC Scotland: SNH Wales: CCW N. Ireland: NIEA	Selection of suitable SSSI sites was more inclusive than exclusive, therefore may overestimate the total land area requiring management. Slightly different selection methodologies for the four countries due to differences in what is recorded in databases.
Woodland Priority Habitats	Includes *Wet woodland; Upland Oakwood; Lowland Beech & Yew woodland; Upland Mixed Ashwoods.* All are either farm woodland or non-farm woodland priority habitats. These PHs are combined as they all fall under the same generic management option.	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventories (some partial) for England (NE).	Only have mapped habitat inventories for England, therefore assessment of overlaps with these habitats can only be done for England. Estimates will be made for other countries.
Other woodlands	Ancient woodland inventories and Forests from Corine land cover 2000 data. These datasets were used to provide a more comprehensive estimate of total woodland cover in the UK, particularly where mapped PH data were lacking.	Ancient woodland inventories from MAGIC, SNH, CCW and Woodland Trust. Corine data from European Environment Agency.	Woodland coverage from these datasets will overestimate land area requiring management, but a percentage can be taken and targeting focussed on woodland PH areas.
Lowland grassland Priority Habitats	Includes *Lowland Calcareous grassland; Lowland Dry Acid grassland; Lowland Meadows.* These are considered to be agricultural PHs. These PHs are combined as they all fall under the same generic management option.	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.

		(CCW).	
Upland grassland Priority Habitats	Includes *Upland Calcareous grassland; Upland Hay Meadows.* These are considered to be agricultural PHs. These PHs are combined as they all fall under the same generic management option.	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Lowland Heathland Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Upland Heathland Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Blanket Bog Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Lowland Raised Bogs Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Purple moor grass and rush-pasture Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE)	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales

		and mapped for Wales using national Phase 1 data (CCW).	data.
Coastal & Floodplain Grazing marsh Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Lowland wood pasture & parkland Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Cereal field margins Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk).	No mapped data for any country. Cannot estimate overlaps.
Hedgerows Priority Habitat	Considered to be an agricultural PH	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). From Countryside Survey (2007) data.	No mapped data for any country. Cannot estimate overlaps.

Figure 7 shows the spatial distribution of biodiversity (habitat) indicators but is limited by the lack of available mapped data for Scotland and N Ireland as noted in Table 14 (limitations).

Figure 7: Spatial extent of indicators relating to policy objective 1.a

(b) Achieving relevant targets for widespread farmland and woodland BAP priority species

We have used the existing targeting maps produced by RSPB led consortium[18] as a guide to areas which appear to be important for currently holding assemblages of priority bird species (Figure 8). This is detailed in Table 15for arable and grassland assemblages. Woodland assemblages coincide with woodland and as such are already mapped under BAP Priority Habitats. Also, there are currently no species-specific stewardship options for woodland.

Table 15: Achieving targets for farmland BAP priority species

Indicator	Rationale & methodology	Data source	Limitations
Grassland Assemblage	The existing targeting maps produced by the RSPB consortium were used as a guide to areas that appear to be important for currently holding assemblages of priority bird species. These were taken as starting point for the selection of species to include in the assemblages. In instances where the bird species included in the England assemblage does not occur or has limited distribution in the other regions, a substitute species was used. Final list of species used also depended on availability of data. For grassland assemblage, species used across all countries are: Curlew; Lapwing. For England, Scotland & NI, Redshank; Snipe also used. Yellow wagtail an additional species for England, and Corncrake additional for Scotland and NI. Buffered areas were selected if 2 or more of these species were incident (since only 2 with available data in Wales). Land area restricted to that under agriculture or woodland (from CORINE landcover).	RSPB (Bird Conservation Targeting Project) Locations of target species with a 2km buffer.	Lack of species data for Wales may restrict suitable land area in this country. Variable coverage of Scotland.
Arable Assemblage	The existing targeting maps produced by the RSPB consortium were used as a guide to areas that appear to be important for currently holding assemblages of priority bird species. These were taken as starting point for the selection of species to include in the assemblages. In instances where the bird species included in the England assemblage does not occur or has limited distribution in the other regions, a substitute species was used. Final list of species used also depended on availability of data. For arable assemblage, species used across all countries are Lapwing & Tree sparrow. Corn bunting additional for England & Scotland; Grey partridge for all but NI; Turtle dove & Yellow wagtail for England and Yellowhammer for all but England. Buffered areas were selected if 4 or more of these species were incident. Land area restricted to that under agriculture or woodland (from CORINE landcover).	RSPB (Bird Conservation Targeting Project) Locations of target species with a 2km buffer.	Only 4 species in assemblage list for Northern Ireland. Variable coverage of Scotland.

[18] http://www.rspb.org.uk/ourwork/conservation/projects/targeting/targeting_maps.asp N.B. The data for Scotland are largely based on contributions from the Scottish Ornithologists Club (SOC) in Argyll, Clyde, Highland and North East Scotland. The low number of records for other parts of Scotland means that the maps do not reflect the true distribution of species in Scotland.

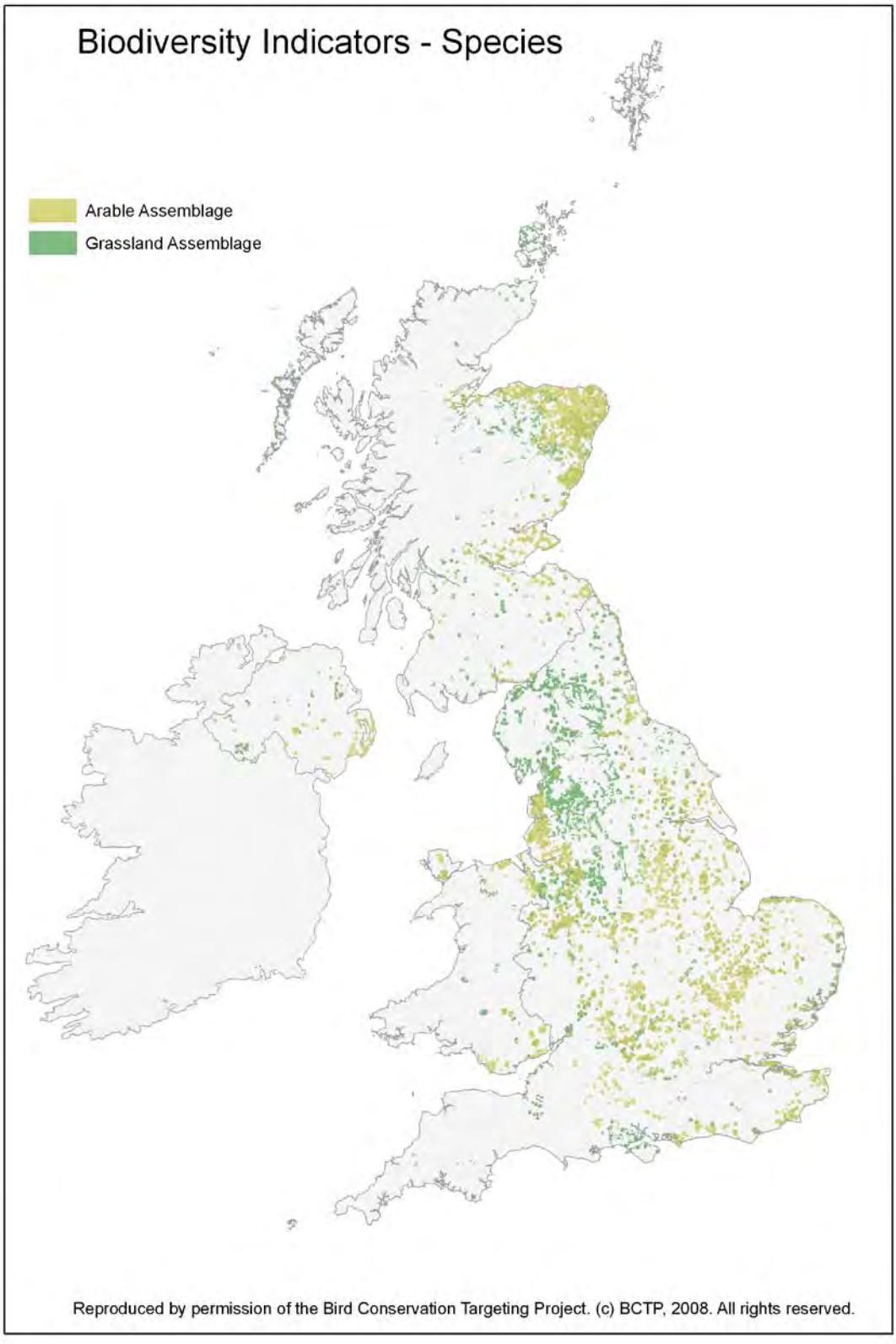

Figure 8: Spatial extent of Arable and Grassland Assemblage indicators

(c) Increasing landscape permeability/connectivity by establishing buffers/green infrastructure etc to help allow biodiversity to adapt to climate change

As set out in table 3, we have used a buffer area around existing assemblages and habitats to quantify and locate new green infrastructure.

Table 16: Increasing landscape permeability/ connectivity

Indicator	Rationale & methodology	Data source	Limitations
3km buffer around SSSIs/ PHs/ assemblages	The priority would be to target actions to those areas of the UK where priority habitats or species do not necessarily already exist but where additional action needs to be taken to encourage them to occur more widely than their current range. Best to encourage enhancement in vicinity of existing resource. For this reason, 3km buffers were created around all areas from (a) & (b) (excluding non PH woodland) and area calculations restricted to that under agriculture or woodland (from CORINE landcover).	N/A	Covers a large area and not necessarily always the best locations to target establishment of green infrastructure, but represents best spatial approach we could take.

(d) Woodland creation to meet published targets

No relevant spatial indicators are available, with the exception of Northern Ireland, for which a boundary of land suitable for new woodland creation with possible constraints (from Forest Service department of DARDNI) was used. We have not been able to source similar datasets for the other regions. Coverage of land on which woodland creation is likely to take place is therefore based on the published targets, without spatially targeting.

2. Landscape

(a) Maintenance of landscape character and quality, focused on areas of high existing landscape value

Designated areas of landscape value and associated datasets (where available) are set out in table 4.

Table 17: Maintenance of landscape character and quality

Indicator	Rationale & methodology	Data source	Limitations
AONBs/ NSAs	Areas of Outstanding Natural Beauty and National Scenic Areas in Scotland are designated for their landscape and scenic beauty. Land area under this designation restricted to that under agriculture or woodland (from CORINE landcover).	England: MAGIC Scotland: SNH Wales: CCW N. Ireland: NIEA	None
National Parks	Of equal importance to AONBs for landscape and scenic beauty. National Park authorities have special powers to conserve & enhance. Land area under this designation restricted to that under agriculture or woodland (from CORINE landcover).	England: MAGIC Scotland: SNH Wales: CCW	There are currently no National Parks in Northern Ireland
National Trust owned land	Also potentially important landscapes. Land area restricted to that under agriculture or woodland (from CORINE landcover).	National Trust	No data for Scotland
World Heritage Sites	Designated by the World Heritage Committee. Land area restricted to that under agriculture or woodland (from CORINE landcover).	England: MAGIC Scotland: SNH Wales: CCW	Not just designated for landscape value
Parks & gardens	Land area restricted to that under agriculture or woodland (from CORINE landcover).	England: English Heritage Scotland: Historic Scotland Wales: Cadw N. Ireland: NIEA	Datasets vary between countries in terms of their inclusions
ESAs	Environmentally Sensitive Areas have particularly high landscape, wildlife or historic value. They include some areas not covered by statutory designations, hence their inclusion. Land area restricted to that under agriculture or woodland (from CORINE landcover).	England: Natural England Scotland & Wales: Countryside Information System	No data for Northern Ireland
Stone walls	Contribute to landscape value	Countryside Survey (2007)	Statistical estimate based on CS data.

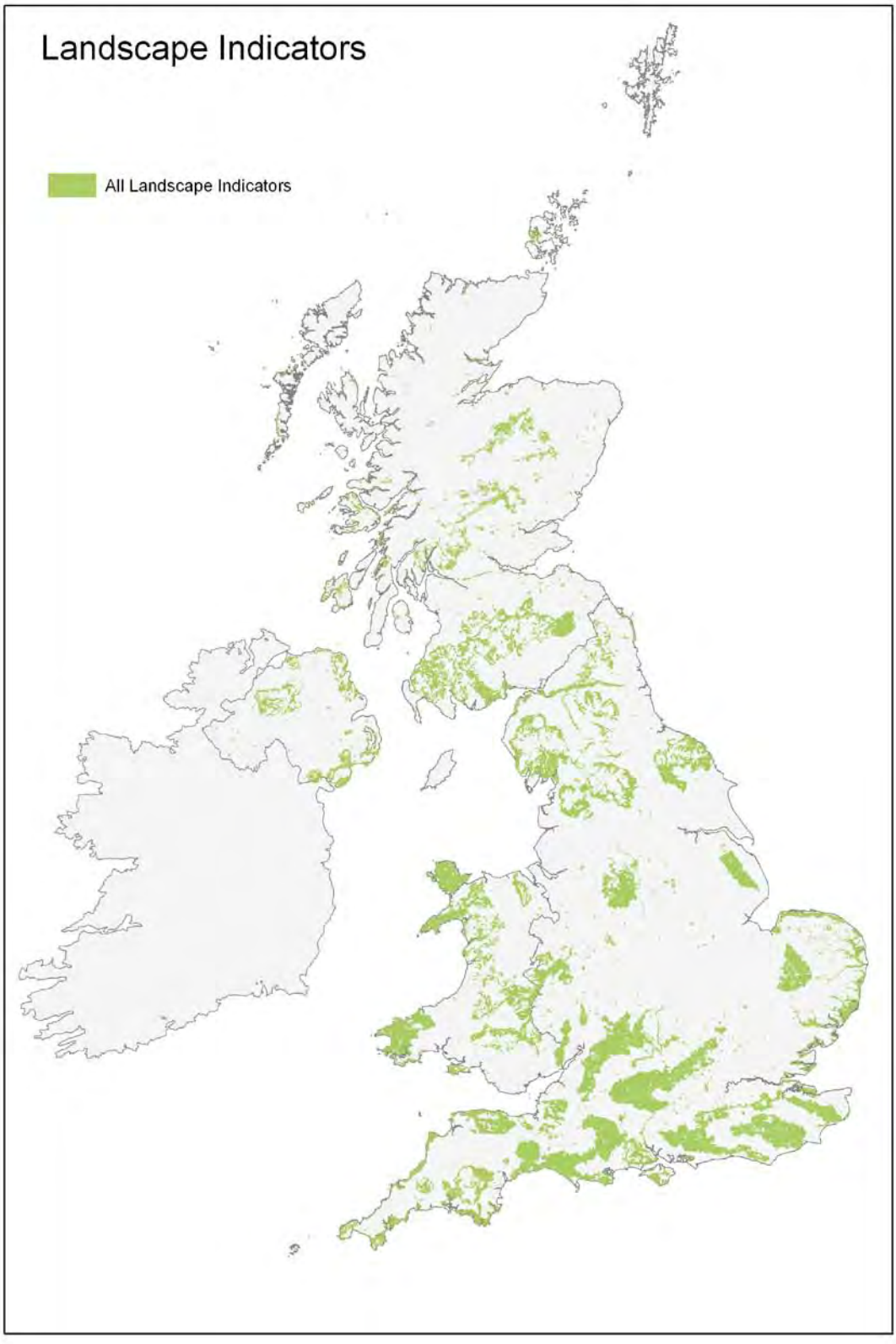

Figure 9: Spatial extent of the designated areas of landscape value in Table 12

3. Climate change mitigation

(a) Protect existing major carbon stores (peat, wetlands, woodlands, soils)

Table 18: Protect existing major carbon stores

Indicator	Rationale & methodology	Data source	Limitations
Blanket Bog & Lowland Raised Bog Priority Habitats	High peat content habitats; peat is also a major carbon store.	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Peat soils	The European Soils Database was used to select areas with peat soils. This indicator was included as not all high peat areas are covered by PH designation.	European Commission – Joint Research Centre (JRC)	Data mapped at 1:1,000,000 resolution; therefore accuracy is not as good as national soil datasets; however the European data is freely available for use.
Woodland	Woodland is another major carbon store. Forested area from Corine land cover 2000 data, Ancient Woodland and the National Inventory of Woodland and Trees (NIWT) to provide more comprehensive estimate.	Ancient woodland inventories from MAGIC, SNH, CCW and Woodland Trust. NIWT data from Forestry Commission. Corine data from European Environment Agency.	None

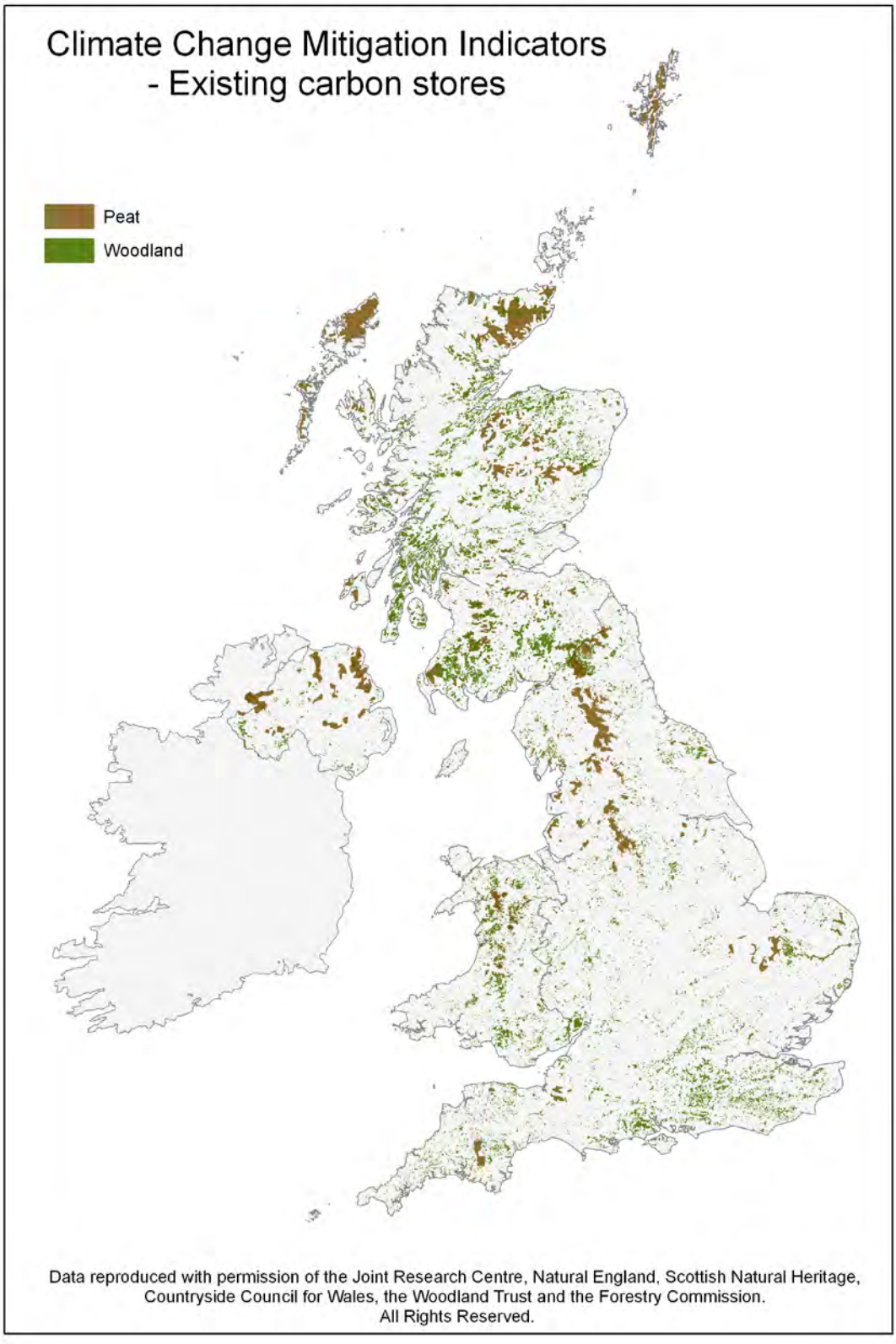

Figure 10: Spatial extent of the climate change mitigation indicators shown in Table 13

(b) Carbon sequestration – provide energy crops for renewable energy

There is no available indicator for renewable energy crops. We could allocate areas around existing plantings (data only available for England) or biomass/ co-firing plants, but theoretically energy crops could be planted on a range of agricultural land[19]. We propose that coverage of land on which energy crops are likely to be planted is based on the published targets without spatially targeting.

(c) Reduce carbon equivalent greenhouse gas emissions from agriculture (as per the broad targets set out in the Climate Change Act 2008)

Table 19: Reduce greenhouse gas emissions from agriculture

Indicator	Rationale & methodology	Data source	Limitations
Carbon Dioxide emissions	Emissions from agriculture, forestry and land use change are available as pollutant-specific gridded emissions for year 2006 by CORINAIR SNAP sectors. All gases are available on a 1km grid. The top 10% was taken as indicative of the areas with the highest emissions.	National Atmospheric Emissions Inventory	Choice of threshold is arbitrary. 10% used but could be based on particular value.
Ammonia emissions			
Nitrous Oxide emissions			
Methane emissions			

[19] There is currently work in N Ireland in relation to likely areas for energy cropping, & a public consultation on Cross-Departmental Bioenergy Action plan (http://www.detini.gov.uk/cgi-bin/moreutil?utilid=1223)

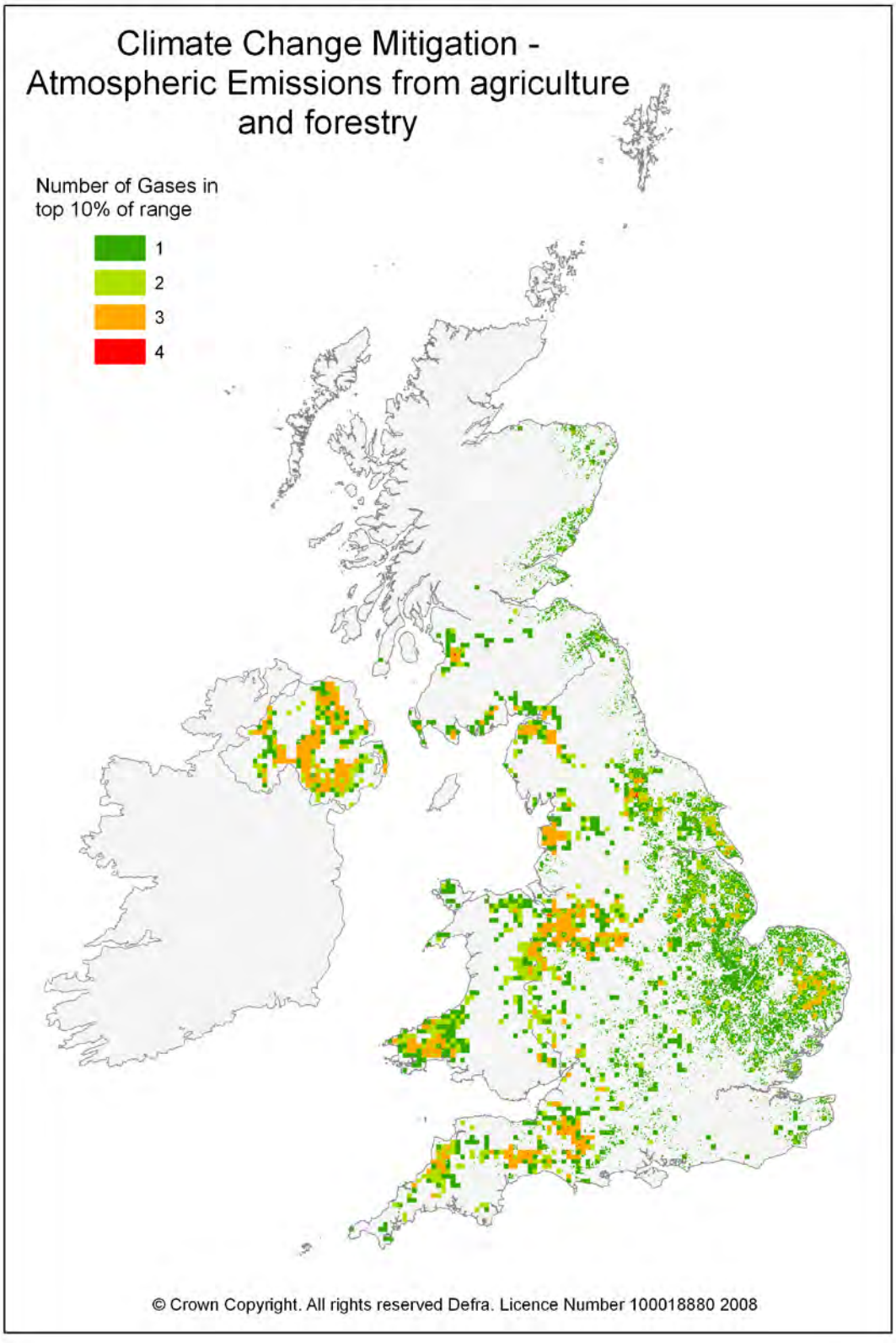

Figure 11: Spatial extent and extent of overlap of the GHG indicators (CO_2, NH_3, N_2O & CH_4)

4. Flood Risk Management

(a) Adaptation to flood risks – reducing run-off from upland catchments

Table 20: Adaptation to flood risks – reducing run-off from upland catchments

Indicator	Rationale & methodology	Data source	Limitations
Agricultural areas with high SPR in uplands	Agricultural areas above 250m (moorland line) that overlaid soils with a Hydrology of Soil Types (HOST) class having a Standard Percentage Runoff (SPR) value of >40% were mapped. These soils are likely to have highest runoff potential due to their structure and composition. SPR represents the fraction of rainwater that is likely to undergo surface transport, contributing to runoff. HOST class was obtained from the European soils data, and linked to the soil mapping unit. SPR values for each HOST class were obtained from the Institute of Hydrology Report No. 126.	Corine landcover data from European Environment Agency. Moorland line from MAGIC & CCW. Areas above 250m in Scotland and N. Ireland derived from 50m digital terrain models. Soils data from European Commission – Joint Research Centre (JRC)	Does not take into account slope or landcover

(b) Provision of water storage capacity in the lowlands

Table 21: Provision of water storage capacity in the lowlands

Indicator	Rationale & methodology	Data source	Limitations
Coastal & Floodplain Grazing marsh Priority Habitat	A priority habitat that is likely to provide water storage capacity and thus requires maintenance.	Latest figures taken from national status estimates from 2008 reporting (www.ukbap-reporting.org.uk). Mapped inventory for England (NE) and mapped for Wales using national Phase 1 data (CCW).	No mapped data at a useful scale for Scotland and Northern Ireland. Estimates of overlaps will have to be made from England & Wales data.
Lowland Ramsar sites	Ramsar sites are wetlands of international importance designated under the Ramsar Convention. Many Ramsar sites are also SPAs. These wetlands also provide water storage capacity. Ramsar sites below the moorland line were included.	JNCC	None
Flood risk zones	Flood risk zones are areas that vulnerable to flooding during extreme events due to fluvial (river) flooding. Flood zones for event sizes of up to 1:1000 years were used. It is possible that certain areas within the flood risk zones could be removed from agricultural management to provide water storage capacity.	England & Wales: Environment Agency Scotland: SEPA	The flood map for N. Ireland could not be made available to us without considerable cost; therefore a surrogate of areas up to 10m above sea level was used.

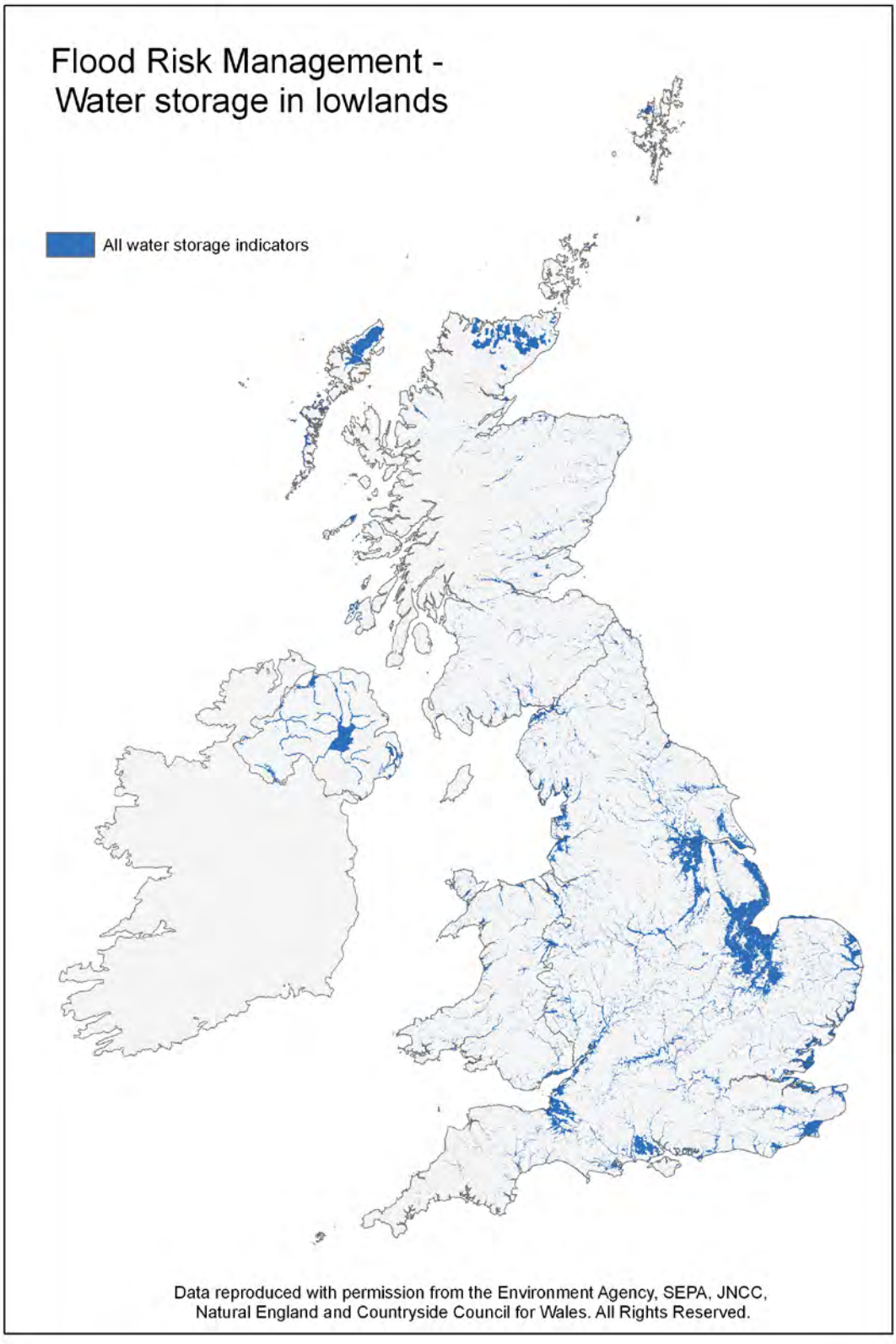

Figure 12: Spatial extent of the indicators for water storage capacity in the lowlands.

(c) Managed retreat on eroding coastlines/inland

The Environment Agency does not hold a national spatial dataset on the locations of managed retreats. Shoreline Management Plans (SMPs) are large-scale assessments of the risks associated with coastal processes, including erosion. The entire coastline of England and Wales has been divided into sections, each having its own SMP. These are not defined in areal units, but could give an indication of the length of coastline that is at risk from erosion, and thus the need for the construction of managed retreats. SMP data are held locally and were therefore not sourced for this project.

5. Farmland historic environment

(a) Protection of scheduled and undesignated sites in farmland and woodland, including historic farm buildings

Table 22: Protection of scheduled and undesignated sites

Indicator	Rationale & methodology	Data source	Limitations
Scheduled monuments and areas	These include designated sites of historical importance. Those sites under agricultural or woodland land use were selected. 'Areas of significant archaeological interest' was an additional dataset available for Northern Ireland.	England: English Heritage Scotland: Historic Scotland Wales: Cadw N. Ireland: NIEA	Does not include undesignated sites
Listed buildings	Farm buildings only were selected from these data. Most is point data, but some polygon data exists for England. An average area of farm buildings from the polygon dataset was used to estimate the land area covered by the point data.	England: English Heritage Scotland: Historic Scotland Wales: Cadw N. Ireland: NIEA	Farm buildings were selected by wildcard search on the building name; therefore some may have been missed.

6. Soil quality

(a) Build soil organic matter/carbon to protect soil quality

Table 23: Build soil organic matter/ carbon to protect soil quality

Indicator	Rationale & methodology	Data source	Limitations
Soil erosion risk >2t/ha/yr	The Pan European Soil Erosion Risk Assessment (PESERA) project produced a 1km gridded map based on a model combining the effects of topography, climate and soil into a single integrated forecast of run-off and soil erosion. Sediment losses of >2t/ha/yr are considered unsustainable (published research), therefore 1km cells above this threshold were selected for inclusion in the indicator. Land area restricted to that under agriculture or woodland (from CORINE landcover).	European Commission – Joint Research Centre (JRC)	Only at 1km resolution. Only estimates loss of soil from water erosion.
Organic carbon content ≤2%	A refined pedo-transfer rule for calculating the OC content of topsoil in Europe has been applied to a 1km soil dataset, derived from the European Soils	European Commission – Joint Research	Only at 1km resolution. Some debate as to

on arable land	Database, a digital elevation model and mean annual temperature data. It is widely believed that a major threshold is 2% soil OC content, below which potentially serious decline in soil quality will occur (published research), therefore 1km cells below this threshold, and that were located on arable land were selected for inclusion.	Centre (JRC)	whether or not a direct link between OC content and soil quality can be made.

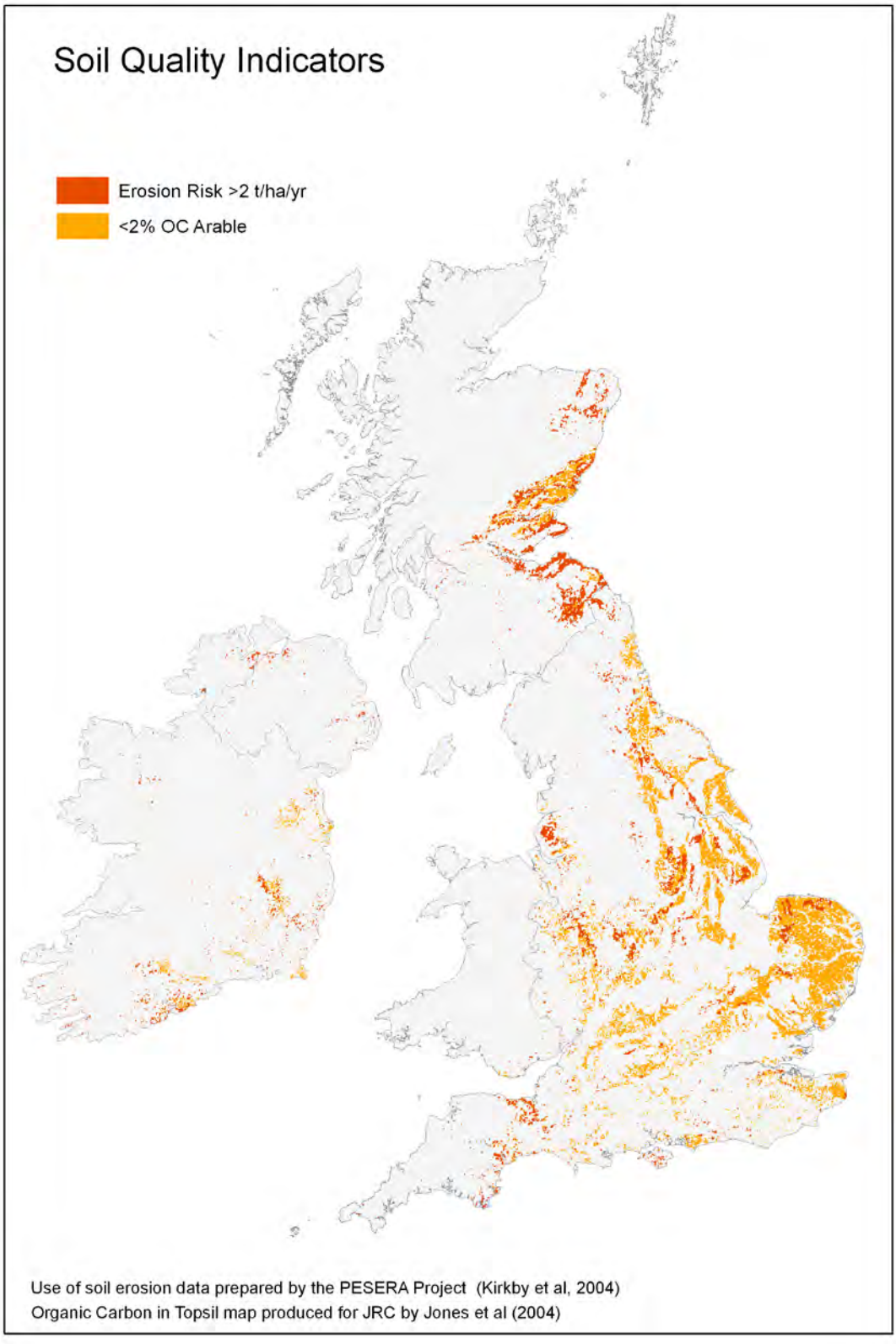

Figure 13: Spatial extent of soil quality indicators

7. Water quantity – management and efficiency

(a) Sustainable use of water resources, adaptation of management practices that maximise efficient use of water in the face of climate change

We intended to use Catchment Abstraction Management Plans from the Environment Agency as the indicator for this objective. However this data has not been forthcoming and in its absence we have used data from another source.

Table 24: Sustainable use of water resources

Indicator	Rationale & methodology	Data source	Limitations
Agricultural demand >100% of available surface water	This used outputs of Defra project WU0108 – Impact of Climate Change on the Availability of Surface water for Agricultural use in England & Wales. The output used was agricultural demand as percentage of available water during summer (June to August) in an average year, which was mapped on a 1km grid. Cells with >100% demand were selected as being unsustainable.	ADAS model output	Only considers surface water and agricultural demand. Requires permission from Defra to use project output data.

8. Resource protection – achieve WFD water quality objectives

(a) Reduce sediment loading due to run-off and soil erosion

Table 25: Reduce sediment loading due to run-off and soil erosion

Indicator	Rationale & methodology	Data source	Limitations
Soil erosion risk >2t/ha/yr	The Pan European Soil Erosion Risk Assessment (PESERA) project produced a 1km gridded map based on a model combining the effects of topography, climate and soil into a single integrated forecast of run-off and soil erosion. Sediment losses of >2t/ha/yr are considered unsustainable (published research), therefore 1km cells above this threshold were selected for inclusion in the indicator. Land area restricted to that under agriculture or woodland (from CORINE landcover).	European Commission – Joint Research Centre (JRC)	Only at 1km resolution. Only estimates loss of soil from water erosion.
WFD 'at risk' catchments	Article 5 of the EC Water Framework Directive requires assessment of pressures and impacts on water bodies. Where the pressures are found not to meet good status, then it is deemed to be "at risk". Pressures from diffuse and point pollution from agriculture or forestry were considered for this project. These arise from nutrients; organic matter, ammonia and faecal pathogens; toxic substances (e.g. pesticides) and sediment. Area calculations relate to those parts of the	England & Wales: Environment Agency* Scotland: SEPA N. Ireland: NIEA	Risk assessment data relate to the whole catchment therefore targeting cannot be at a finer spatial scale. Specific pressures cannot always be identified from the data (i.e. from nutrients, sediment etc.) WFD catchment boundaries could not be provided for Scotland, England or Wales

	catchments under agriculture or forestry.		due to licensing issues. In these cases we used the midpoints of the catchments and linked these to a freely available catchment dataset. *Data from Environment Agency (risk assessments and catchment midpoints) were not forthcoming; therefore the alternative (BAUIII models) was used.
BAUIII sediment loading models	Outputs from Defra project SFF0601. Export coefficient model results applied to 10km grid cells, for which data on land cover, cropping and stocking, soil type and climatic zones had been calculated. Output was total sediment loss per 10km grid cell (kg/ha) for the baseline year (2004), including the effect of mitigation method implementation. An arbitrary threshold of 280kg per ha (top 10% of range) was used. This provides an alternative or a supplement to WFD catchment risk assessments, and will provide further information as to the dominant agricultural pressures in at risk catchments.	ADAS model output	Requires permission from Defra to use project output data. 2004 data used, but could use 2010 projections based on Business As Usual forecasts.

(b) Reduce diffuse nutrient pollution of water

Table 26: Reduce diffuse nutrient pollution of water

Indicator	Rationale & methodology	Data source	Limitations
WFD 'at risk' catchments	Article 5 of the EC Water Framework Directive requires assessment of pressures and impacts on water bodies. Where the pressures are found not to meet good status, then it is deemed to be "at risk". Pressures from diffuse and point pollution from agriculture or forestry were considered for this project. These arise from nutrients; organic matter, ammonia and faecal pathogens; toxic substances (e.g. pesticides) and sediment.	England & Wales: Environment Agency* Scotland: SEPA N. Ireland: NIEA	Risk assessment data relate to the whole catchment therefore targeting cannot be at a finer spatial scale. Specific pressures cannot always be identified from the data (i.e. from nutrients, sediment etc.) WFD catchment boundaries could not be provided for Scotland, England or Wales due to licensing issues. In these cases we used the midpoints of the catchments and linked these to a freely available catchment dataset. *Data from Environment Agency (risk assessments and catchment midpoints) were not forthcoming; therefore the alternative

			(BAUIII models) was used.
BAUIII phosphorous & nitrate loading models	Outputs from Defra project SFF0601. Export coefficient model results applied to 10km grid cells, for which data on land cover, cropping and stocking, soil type and climatic zones had been calculated. Output was total phosphorous & nitrate loss per 10km grid cell (kg/ha) for the baseline year (2004), including the effect of mitigation method implementation. Arbitrary thresholds of 1kg/ha of P and 30kg/ha of N (top 10% of ranges) was used. This provides an alternative or a supplement to WFD catchment risk assessments, and will provide further information as to the dominant agricultural pressures in at risk catchments.	ADAS model output	Requires permission from Defra to use project output data. 2004 data used, but could use 2010 projections based on Business As Usual forecasts.

Table 27: Reduce pesticide pollution of water

Indicator	Rationale & methodology	Data source	Limitations
WFD 'at risk' catchments	Article 5 of the EC Water Framework Directive requires assessment of pressures and impacts on water bodies. Where the pressures are found not to meet good status, then it is deemed to be "at risk". Pressures from diffuse and point pollution from agriculture or forestry were considered for this project. These arise from nutrients; organic matter, ammonia and faecal pathogens; toxic substances (e.g. pesticides) and sediment.	England & Wales: Environment Agency Scotland: SEPA N. Ireland: NIEA	Risk assessment data relate to the whole catchment therefore targeting cannot be at a finer spatial scale. Specific pressures cannot always be identified from the data (i.e. from nutrients, sediment etc.) WFD catchment boundaries could not be provided for Scotland, England or Wales due to licensing issues. In these cases we used the midpoints of the catchments and linked these to a freely available catchment dataset.

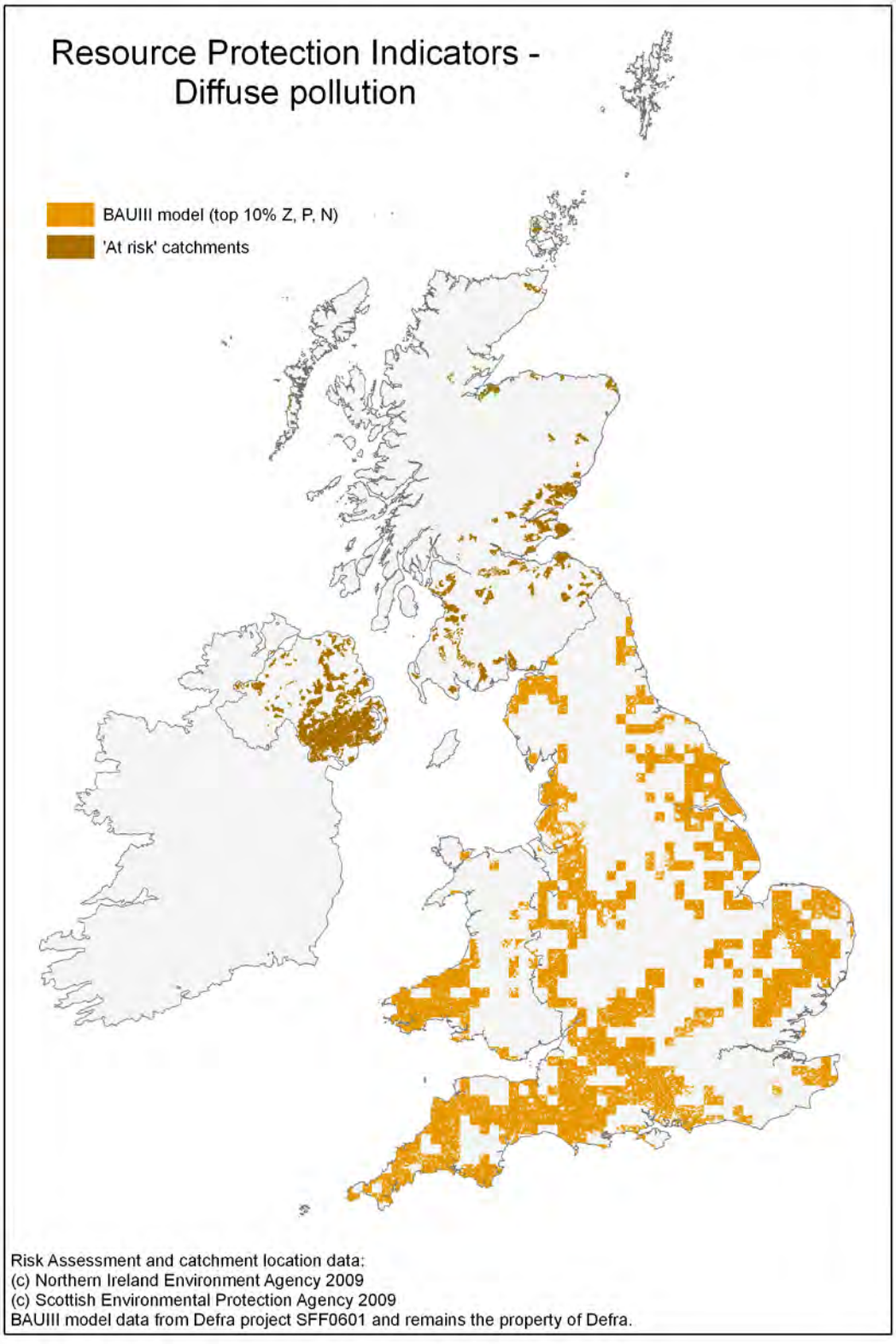

Figure 14: Spatial extent of resource protection indicators relating to diffuse agricultural pollution

(c) Reduce water pollution from livestock (faecal indicator organisms)

Table 28: Reduce water pollution from livestock

Indicator	Rationale & methodology	Data source	Limitations
WFD 'at risk' catchments	Article 5 of the EC Water Framework Directive requires assessment of pressures and impacts on water bodies. Where the pressures are found not to meet good status, then it is deemed to be "at risk". Pressures from diffuse and point pollution from agriculture or forestry were considered for this project. These arise from nutrients; organic matter, ammonia and faecal pathogens; toxic substances (e.g. pesticides) and sediment.	England & Wales: Environment Agency Scotland: SEPA N. Ireland: NIEA	Risk assessment data relate to the whole catchment therefore targeting cannot be at a finer spatial scale. Specific pressures cannot always be identified from the data (i.e. from nutrients, sediment etc.) WFD catchment boundaries could not be provided for Scotland, England or Wales due to licensing issues. In these cases we used the midpoints of the catchments and linked these to a freely available catchment dataset.
Manure loads	The ADAS manures management database (MMDB) uses ADAS 1km stocking data (from agricultural census) to make estimates of the amount (kg) of manure applied or directly voided to land by livestock type and land use based on empirically derived coefficients. The MMDB data was used to select 1km cells that have the highest loading of livestock excreta (top 10%), and thus the greatest likelihood of FIOs from livestock. This provides an alternative or a supplement to WFD catchment risk assessments, and will provide further information as to the dominant agricultural pressures in at risk catchments.	ADAS	Indicator is loading of excreta to land rather than specifically FIOs, but should be strongly correlated to FIO prevalence.

Figure 15: Top 10% of livestock manure loading to land as an indicator of areas of highest risk of water pollution from livestock

9. Management of land for public access

(a) Providing permissive access routes that help to link up the existing statutory network

There is not a suitable spatial indicator for this objective. Instead we have used information on the length of public rights of way in England and Wales to make an estimate of the extra access routes that would need to be created to meet the objective (e.g. as a percentage of existing length). There are no public rights of way in Northern Ireland, and access is permitted everywhere in Scotland.

The following estimates have been used:

- England – 1% of existing access length
- Scotland – 175 km per year (as advised by SNH)
- Wales – 1% of existing access length
- N Ireland – 10 km per year (agreed with DARD)

Appendix 4: Quantification of Indicator Overlaps

Each selected indicator that had associated spatial data in the form of polygons were converted to raster grids with a 100x100m (1 ha) pixel size. A pixel was classified as being positive (1) for the indicator if at least 50% of its area was covered by the indicator, otherwise it was classified as negative (0) for that indicator. Rasterising the polygon data provides a simpler means of estimating area of overlap (using raster calculator) for any combination of indicators.

Indicators with spatial data were overlaid in turn to determine whether or not they overlap (see matrix at Figure 16). Each pairwise combination of indicators in the matrix was considered. For each pair of indicators, there are two key possibilities:

(i) If there was no or negligible overlap, then management options that apply to these indicators are discrete and no further analysis was required.

(ii) If the indicators overlapped spatially, the indicator areas have been adjusted according to which of the following three options apply:

- management options are different but complementary (*'distinct options'*), the area of overlap was counted under both objectives and no further analysis was required
- management options are the same or similar enough for them to be addressed by a single prescription (*'combined options'*), the area of overlap was subtracted from the combined indicator areas to avoid double counting. In these cases, the combined option was defined. This could be one or other of the options already assigned to the indicator, or a new option incorporating both
- management options are conflicting (*'incompatible options'*), only one option was considered for the overlapping area. In this case, the area of overlap was subtracted from the other indicator area.

Identification of areas where more than two indicators overlap was required for combined and incompatible options to avoid double counting of overlapping areas, as they are not necessarily discrete. This was done by first creating new raster grids for just the areas of overlap of relevant paired indicators. For each indicator in turn, the overlap area to be discounted from the total area of that indicator (i.e. where the scheme option relating to that indicator will not be applied) was merged using spatial analysis tools. The resulting grid was reclassified and queried to provide an area for the merged overlap, which was then subtracted from the total area of the indicator in question (see Figure 17 for illustration).

This process was repeated for each country in turn. Where spatial data were missing for a particular country (i.e. BAP Priority habitats for Scotland and Northern Ireland), the combined PH / non-PH indicator overlap for England as a proportion of the total non-PH indicator area was applied to the total non-PH indicator area for the other country. This provided an estimate of the area of overlap.

Policy Objective																														
	Indicator	SSSI	BB	LRB	LG	UG	LH	UH	CFGM	PMGRP	Wood	WW	GraAss	AraAss	Buff	LWP	LS	Wood	Peat	GHG	AgUp	WS	MR	HS	HRAS	HWD	SER	ARC	MMDB
Biodiversity	SSSIs (ASSIs in N Ireland)																													
Biodiversity	Blanket Bog	D																												
Biodiversity	Lowland Raised Bogs	D																												
Biodiversity	Lowland grassland: GENERIC	D																												
Biodiversity	Upland grassland: GENERIC	D																												
Biodiversity	Lowland heathland	D																												
Biodiversity	Upland heathland	D																												
Biodiversity	Coastal & Floodplain Grazing marsh	D																												
Biodiversity	Purple moor grass and rush-pasture	D																												
Biodiversity	Woodland: GENERIC	D		I, LRB			I, LH	I, UH		I, PMGRP																				
Biodiversity	Wet woodland PH	D									I,WW																			
Biodiversity	Grassland Assemblage	D		C	C	C	C		C	C	I,GRAASS	C																		
Biodiversity	Arable Assemblage	D		I, LRB	I, LG		I, LH		I, CFGM	I, PMGRP	I, ARAASS	I, WW	D																	
Biodiversity	3km Buffer										C		C	C, ARAASS																
Biodiversity	Lowland wood pasture & parkland	D									C		C	I, LWP	C															
Landscape	Landscape designations: GENERIC	C		C	C	C	C	C	C	C	C	C	C	C, ARAASS	C	C														
Climate Change	Woodland: GENERIC	C		I, LRB			I, LH	I, UH		I, PMGRP	C	C	I, GRAASS	I, ARAASS	C	C	D													
Climate Change	Peat carbon stores: GENERIC	D	D	D	D	D	D	D	C	D	I, WOOD	C	D	I,ARAASS	D		D	I, WOOD												
Climate Change	GHG emissions top 10%	D		C	C	C	C	C	C	C	C	C	D	D	D	C	D	D	D											
Flood Risk	Agricultural areas in uplands	I, SSSI				I, UG		I, UH		I, PMGRP	C		I, GRAASS	I, ARAASS	D		D	C	D											
Flood Risk	Water storage: GENERIC	D	C	C	C		C		C	C	I, WOOD	C	C	I, ARAASS	D		D	I, WOOD		D										
Flood Risk	Managed retreats	D		I, LRB					C	C	I, MR	I, MR	C	I, ARAASS	D		D	I, MR				C								
Historic Environment	Historic sites: GENERIC	D	D		D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D								
Soil Quality	High risk ag soil: GENERIC	D		I, LRB	I, LG		I, LH		C		I, WOOD	I, WW	D	D	D		D	I, WOOD		D	C	C	C	D						
Water Quantity	High water demand	D			D						D		D	D	D		D			D		D		D	D				
Resource Protection	Soil Erosion risk >2t/ha/yr	D		I, LRB	I, LG		I, LH		C		I, WOOD	I, WW	D	D	D		D	I, WOOD		D	C	C		D	C	D				
Resource Protection	At risk WFD catchments	D	I, BB	I, LRB	I, LG	I, UG	I, LH	I, UH	C	I, PMGRP	C	C	C	C, ARAASS	D	I, LWP	D	C	D				C	D	C	D	C, SER			
Resource Protection	MMDB excreta loads top 10%	D	I, BB	I, LRB	I, LG	I, UG	I, LH	I, UH	C	I, PMGRP	D	D	C	C, ARAASS	D	D	D	D	D	C	C	C	C	D	D	D	C, SER	C, ARC		

Key: **C = combined option possible to meet the needs of both objectives, therefore overlap will not be counted twice.**
D = distinct options needed to meet the needs of both objectives in the overlapping area, therefore overlap area will be counted under each. Options must be complementary.
I = options are incompatible and should not be applied on the same area of land. One must be chosen as the most important for the area of overlap.

Notes:
(1) SSSI = basic retainer to recognise importance of having an SSSI designation on land. Additional payments needed to manage the habitats in the SSSI, therefore Distinct
(2) Landscape = basic retainer at farm level to recognise the overall contribution of farm to landscape designation = only relevant to pay this where land not already SSSI or other habitat, therefore a Combined option with priority on the SSSI and other biodiversity designations
(3) Grassland Assemblage. Overlaps with other priority habiatats accepts that those take priority, and contribute to the grassland assemblage goal anyway
(4) Arable Assemblage = focus on more intensive land but cannot have that taking priority over priority habitats
(5) Peat Carbon Stores = supplement for rewetting therefore in most cases this is an additional need to the other options
(6) Because woodland category so broad, then other habitats take priority where overlap occurs (as biodiversity value of those more clear)

Figure 16: Spatial overlap matrix showing allocation of the three options where overlaps occur. Blank cells are cases where there is no or negligible overlap.

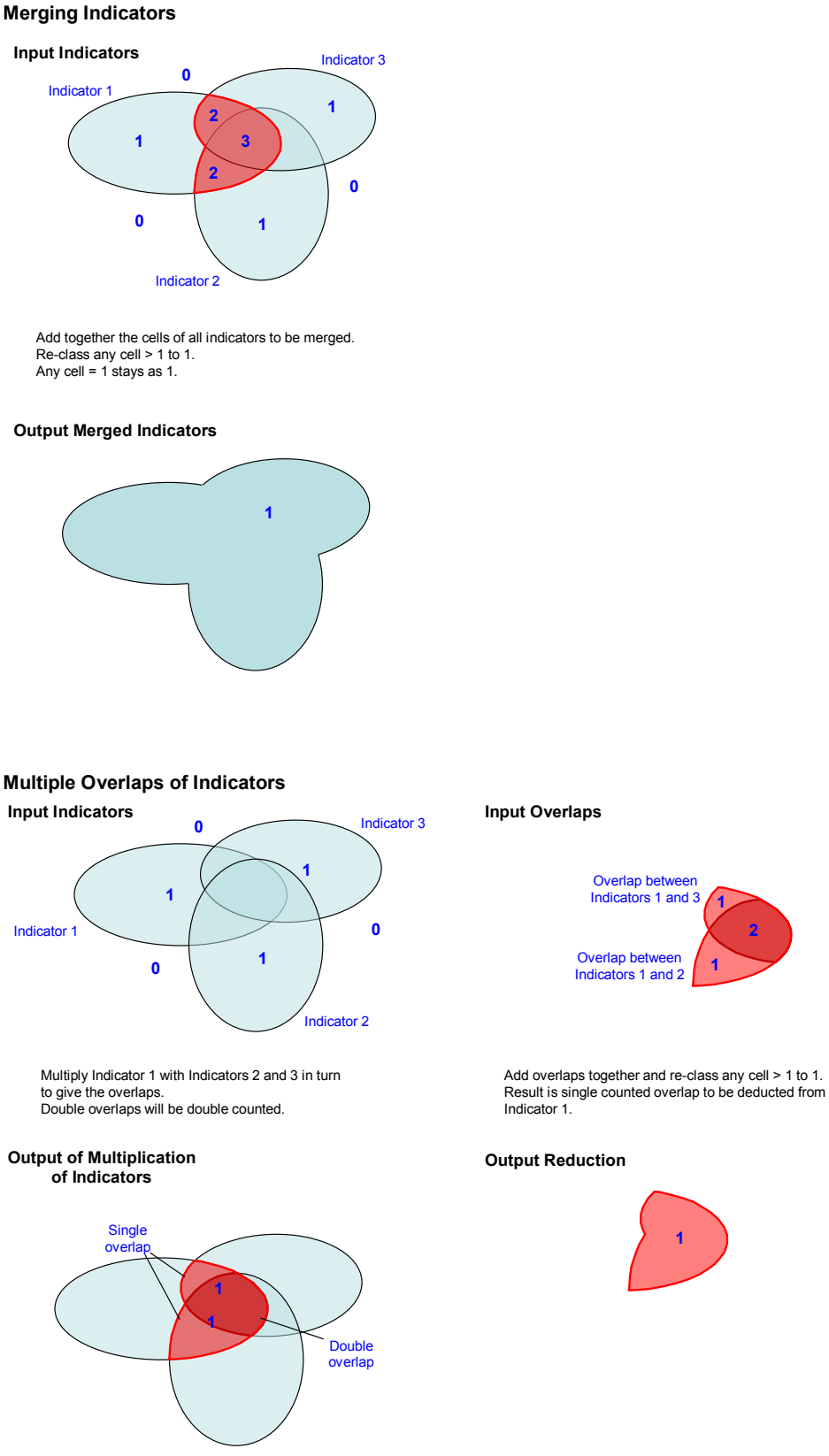

Figure 17: Methodology for dealing with overlaps

Appendix 5: Estimating coverage

Areas (or lengths) of each of the selected indicators as detailed above was calculated in a GIS (or from published estimates where spatial data not available). Where more than one indicator was used for a particular sub-objective, and where the proportion of the area requiring positive management was the same for each indicator, spatial layers were combined to avoid double counting (i.e. where indicators receiving the same management option are overlapping).

The combined indicators and their component parts are shown in Table 29 below.

Table 29: Generic indicators and component parts

Combined Indicator	Component Indicators
Woodland: GENERIC	• Woodland Priority Habitats • Ancient Woodland Inventory • Forests from Corine land cover
Lowland grassland: GENERIC	• Lowland calcareous grassland • Lowland dry acid grassland • Lowland meadows
Upland grassland: GENERIC	• Upland calcareous grassland • Upland hay meadows
Landscape designations: GENERIC	• AONBs • National Parks • National Trust land • World Heritage Sites • Parks & gardens • ESAs
Peat carbon stores: GENERIC	• Blanket bog • Lowland raised bog • Peat soils
GHG emissions (top 10%): GENERIC	• Carbon dioxide emissions • Ammonia emissions • Nitrous oxide emissions
Water storage capacity: GENERIC	• Coastal & floodplain grazing marsh • Lowland Ramsar sites • Flood risk zones
Historic sites: GENERIC	• Scheduled ancient monuments • Scheduled areas • Areas of significant archaeological interest • Listed (farm) buildings
High risk agricultural soil: GENERIC	• Soil erosion risk >2t/ha/yr • Organic carbon content ≤2% on arable land

The percentage coverage required for each indicator was estimated by reference to degree of statutory protection, extent of the indicator area that is at risk or most cost-effective to deliver the outcome.

Table 30: Coverage of scheme options required (by policy sub-objective)

Sub-objective	Extent of coverage (%)	Comments
Priority habitats and species*	100	Statutory designation and reliant on agri-environment schemes to deliver
Biodiversity-landscape permeability/connectivity	50	Based on the fact that only a proportion of the 3km buffer area will require stewardship
Biodiversity-woodland creation	n/a	Based on targets. Links to planting for carbon sequestration or flood mitigation.
Landscape - statutory designation	100	Statutory designation and reliant on agri-environment schemes to deliver
Landscape - stone walls	5	Protected by cross compliance but need for ongoing repair and maintenance over time
Climate change mitigation – carbon stores	100	Peat carbon stores only; woodland will be captured
Climate change mitigation – carbon sequestration	n/a	Based on targets for energy crop planting only**
Climate change mitigation-GHG reduction	10	Based on generic actions to reduce GHG through best practice and targeted at top 10% of emitters
Flood risk management-reducing run-off from upland catchments	20	Awaiting analysis of PSYCHIC model
Flood risk management-water storage capacity in the lowlands	100	Flood Risk Maps
Flood risk management-retreat on eroding coastlines/inland	100	Shoreline Management Plans
Farmland historic environment-protection of scheduled and undesignated sites	100	Statutory designation and reliant on agri-environment schemes to deliver
Soil quality-organic matter/carbon	20	Low C / High erosion risk ag soil. Targeted at arable land area - one in five year rotation or 20% area to permanent grass
Water quantity-sustainable management and efficiency	n.a.	In the absence of EA data on Catchment Abstraction Management Plans, ADAS data on agricultural water demand was used
Resource protection-reducing sediment loading	100	Soil Erosion risk >2t/ha/yr as Indicator
Resource protection-reducing diffusion pollution	50	Arable land in Priority Catchments; one field border as buffer or 1 year in 2 as spring-sown crop
Resource protection-reducing pollution from livestock	100	Manures Management Database as Indicator – targeted to top 10% concentration
Public access-providing permissive access routes	n/a	Based on 1% of asset in England and Wales and targets in Scotland and N Ireland. Costed but not spatially mapped.

* published targets for key policy objectives on biodiversity (https://www.ukbap-reporting.org.uk). The 2008 area may be higher or lower than the target area; we have used the 2008 data. All at 100% except Hedgerow [coverage is based on targeting the two-thirds of the UK inventory which is in sub-optimal condition over a four year cycle (67% x 25% = 17%)] and woodland [10% of total woodland area managed annually for biodiversity].

** Other options such as woodland planting, buffer strips and arable reversion are not spatially defined and will be driven by other priorities such as biodiversity, flood risk etc.

**** WFD data from EA is outstanding; BAUIII data is plan B

This single percentage coverage coefficient has been applied at country level was multiplied by the total units for each indicator to provide an estimate of the area of land (length of feature) where positive environmental management is required.

Appendix 6: Assigning scheme options and costs

The method used to assign a single (generic) scheme option to each policy objective was as follows:

(i) Generate a comprehensive database of environmental stewardship options from the four countries. This was constructed from a combination of website listings and publications and included the following criteria:

- Identifier - title and code
- Intensity - cost and unit of cost
- Maintenance or Creation

(ii) Allocate each scheme option to one (or more) objectives or sub-objectives. This process linked all options to (at least) one policy objective but was not comprehensive in linking to all possible objectives

(iii) Aggregate scheme options which address the same objective under a 'generic' scheme which broadly meets the needs of the objective. The range of costs has been recorded and a mid-point (approx) used as the generic scheme cost. Where a number of options are needed together, this has been noted and costs aggregated.

For a few objectives there are no current scheme options which address the management prescription required to deliver the policy objective. Where this is the case, we will suggest possible scheme options at a high level.

In practice a pragmatic approach was taken to assigning scheme options to policy objectives; this involved expert input from ADAS and SAC specialists on landscape, resource protection and biodiversity. In most cases the main challenge was dealing with overlaps where a single scheme may address two or more objectives or there was a need to prioritise which objective should take precedence.