Developing Peatland Carbon Metrics and Financial Modelling to Inform the Pilot Phase UK Peatland Code

Report to Defra for
Project NR0165

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Executive Summary

Peatlands represent the most significant terrestrial carbon store in the UK and maintaining them in good condition is important particularly within the context of greenhouse gas accounts associated with land use and land use change. Peatland restoration is necessary to ensure greenhouse gas emissions from peatlands are reduced and emitting peatlands are brought back into optimum functional condition. Peatland restoration for habitat provision and biodiversity, water quality and carbon benefits is increasing, funded by Government initiatives, agri-environment schemes, European funding streams, water companies and the Heritage Lottery Fund. The Peatland Code is being developed as an additional or alternative funding source: a mechanism for businesses to directly sponsor peatland restoration for carbon benefits. The Peatland Code is intended to provide the voluntary standard for peatland restoration projects in the UK to ensure restoration projects deliver tangible climate change mitigation benefits. For the Code to be successful it is imperative that it is founded upon robust scientific and economic evaluations to ensure it is attractive to potential investors, peatland managers, and landowners.

The aim of this project is to address and develop the mechanisms which form the basis of the Code and to assess its current potential to deliver peatland restoration in the UK.

This project comprised four Work Packages (WP). These are summarised below and presented in this report as follows:

1. **UK Metric for Peatland Restoration (WP1):** Further develop the carbon metric at the Code's foundation to ensure estimations of carbon savings from restoration use standard estimates derived from the best data currently available.
2. **Economic Assessment of the Peatland (WP2):** Carry out a full economic assessment of potential Peatland Code project costs, the Code's market potential and its capacity as a mechanism for funding peatland restoration in the UK. This included creation of a spreadsheet-based Financial Tool to support project design and planning.
3. **Potential for Biodiversity in the Peatland Code (WP4):** Assess the potential for biodiversity to be integrated into the Code to address the need for the Code to recognise more formally these additional benefits.
4. **Scoping the Natural Capital Accounts for Peatland (WP3):** Scope the potential and identify the key issues for developing a UK peatland natural capital account.

This project has been able to both improve the carbon metric and integrate this with a field survey protocol. It has further shown the potential and the need for the Code to recognise the wider benefits of peatland restoration while setting out the economic potential and the key issues for developing a UK peatland natural capital account.

UK Metric for Peatland Restoration (WP1)

The field protocol provides a standard operating procedure for assessing peatland condition and links directly to a method for estimating contemporary greenhouse gas emissions and the potential savings made through restoration. The field protocol identifies four peatland conditions: 1) *Near Natural*; 2) *Modified*; 3) *Drained*; 4) *Actively Eroding*. Each Condition Category is associated with a standard Emissions Factor derived from a review and statistical analysis of the carbon flux data currently available (Table 1). Emissions from *Actively Eroding* sites are estimated to be emitting around 24 tCO_2 eq/ha/yr which is an order of magnitude (ten times) greater than sites in the other

Condition Categories. Restoring such sites, stopping them from losing carbon, is therefore key to maximising GHG emissions reductions.

Table 1 Emission Factors for each Condition Category after statistical analysis ($tCO_2eq/ha/yr$) using IPCC default values for DOC and relevant literature for POC. See footnotes for details on how POC and DOC values were derived. *Not enough UK appropriate data from pristine sites exists to give an Emissions Factor, but it is expected to be negative.

Peatland Code Condition Category	Descriptive Statistic	CH_4	CO_2	N_2O	DOC	POC	Emission Factor
Pristine*	-	-	-	-	-	-	**Unknown**
Near Natural	Mean (±StE)	3.2(1.2)	-3.0(0.7)	0.00(0.0)	0.88[1]	0	**1.08**
	Median	1.5	-2.3	0.0			
Modified	Mean (±StE)	1.0(0.6)	-0.1(2.3)	0.5(0.3)	1.14[2]	0	**2.54**
	Median	0.2	0.1	0.5			
Drained	Mean (±StE)	2.0(0.8)	1.4(1.8)	0.00(0.00)	1.14[3]	0	**4.54**
	Median	1.0	-0.9	0.0			
Actively Eroding	Mean (±StE)	0.8(0.4)	2.6(2.0)	0.0(0.0)	1.14[4]	19.3 (average of 14.67[5] and 23.94[6])	**23.84**
	Median	0.1	0.4	0.0			

Economic Assessment of the Peatland Code (WP2)

The strength of the Peatland Code is that it demonstrates quantifiable impacts on greenhouse gas emissions which will make it attractive to a wide range of buyers (Figure 1). Comparisons can be made between the Peatland Code and the well-established Woodland Carbon Code which shows the Code's potential for large scale, immediate carbon savings. To ensure investors' confidence in the Code projects will, however, have to demonstrate additionality and build in risk buffers into the overall cost of a project. Drawing on experiences from the Woodland Carbon Code, sufficient operational costs will also have to be included in project budgets if buyers are to be confident of the monitoring processes and success of a project. As a consequence of these essential project costs, currently it is envisaged that the Peatland Code alone will not provide sufficient funding for peatland restoration projects, with a mix of funding, for instance utilising agri-environment schemes, required (although care needs to taken with respect to the compatibility of different funding sources).

[1] Calculated as the mean value of reported values in UK studies given in Table 2A.2 of the 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement) http://www.ipcc-nggip.iges.or.jp/home/wetlands.html
[2] IPCC Tier 1 default value for drained peatland (best estimate for modified condition)
[3] IPCC Tier 1 default value
[4] IPCC Tier 1 default value for drained peatland (best estimated for actively eroding condition)
[5] Estimated from UK blanket bogs (in Goulsbra, C., Evans, M. & Allott, T. (2013) Towards the estimation of CO_2 emissions associated with POC fluxes from drained and eroding peatlands. In: Emissions of greenhouse gases associated with peatland drainage waters. Report to Defra under project SP1205: Greenhouse gas emissions associated with non-gaseous losses of carbon from peatlands – fate of particulate and dissolved carbon. Report to the Department of Environment, Food and Rural Affairs, UK)
[6] Value from Birnie and Smyth (2013) unpublished, but recalculated to reflect that 70% of POC derived carbon assumed to be reaching the atmosphere with remaining 30% assumed redeposited (Chris Evans *pers. comm*).

Potential for Biodiversity in the Peatland Code (WP4)

Figure 1 SWOT analysis of peatlands as a voluntary carbon tool

Strengths

- Potential scale – could be much greater than woodland creation
- Offers multiple benefits to society
- Has the ability to deliver immediate carbon savings (via avoided losses)
- There are a range of project developers (environmental NGOs, and water companies) already operating with all the necessary skills for implementing projects describing their benefits and monitoring their success
- Many areas of bog in possibly 'friendly' ownership – not economically driven

Opportunities

- The sheer size of the potential UK voluntary carbon market – up to 550mtCO2/yr– and the wide understanding in business and society of the carbon footprint
- If the difficulties of achieving fully accredited status for the carbon market are too great then there is an opportunity in the Corporate Social Responsibility/sponsorship realm
- More integrated government policy (e.g. Zero Carbon Homes allowing PC projects as allowable solutions)

Weaknesses

- Projects may be less accessible to investors and their stakeholders
- It may be more difficult to find meaningful on-site participation activities for stakeholders
- Many projects have complicated land ownership and access rights
- The Peatland Code is a number of years away from achieving the full carbon project quality assurance status of the Woodland Carbon Code Relatively low voluntary carbon price means reliance in part on other sources of project funding likely to continue
- In comparison to Woodland Carbon Code this not a full quality assurance regime meeting national and international carbon project standards

Threats

- Climate change
- Many projects already implemented will not qualify under additionality rules
- General economic sentiment

The most attractive restoration sites will be those where the greatest carbon gains can be demonstrated, such as restoring sites in the *Actively Eroding* Condition Category, although this may potentially cross-subsidise the restoration of other Condition Categories. Potential domestic policies which might use the Code or the metrics in the future range from carbon trading and carbon credits (e.g. from Zero Carbon Homes) to the Carbon Reduction Commitment.

Currently it is not possible to put a monetary value on peatland biodiversity, with no single species or species group sufficiently indicating biodiversity quality consistently across the UK. However, it is widely recognised that biodiversity will be a driver for peatland restoration and an important, and possibly more widely appreciated, message to use to engage with the general public and the business community. Biodiversity could be successfully used as a way of promoting projects, making projects with lower emission savings potential, such as restoring *Modified* to *Near Natural* condition bogs, more appealing if they can demonstrate greater biodiversity potential. To formalise this a simple rating system was developed. This method uses habitat quality, habitat networks and species groups as the markers for assessing the potential a project will have for enhancing biodiversity (Table 2). Evidence for a project to improve each of these features can be gathered concurrently with the developed Field Protocol for assessing peatland condition and greenhouse gas emissions.

Table 2 Illustration of how the measures of biodiversity potential: habitat quality, habitat connectivity and species groups, suggested as the basis for the approach to incorporating biodiversity into the Peatland Code, could be demonstrated by a projected.

Potential to Enhance	Evidence Needed to Demonstrate Project Potential
Habitat Quality (appropriate vegetation composition, structure and micro-topography)[7]	Presence of sphagnum. Presence of hummocky sphagnum micro-topography. Evidence (photos/maps) that shows appropriate bog vegetation exists at the site and that restoration will provide the necessary conditions for its expansion. This can come directly from the Peatland Code field protocol used to identify the Condition Categories (and Emissions Factor) of a site as well as the already required initial desk based aerial survey work.
Habitat Networks	Maps and aerial images showing site connectivity and links to existing bog habitats/peatland restoration sites/designated peatland sites etc. This could come from the air photo analysis required prior to using the Peatland Code protocol.
Species Groups	Evidence that project will target and support habitat provision for one locally or nationally important peatland species or species group.

Scoping the Natural Capital Accounts for Peatland (WP3)

The numerous and distinct ecosystem services provided by peatlands mean that it is essential to treat peatland as a specific asset within the UK environmental accounts. Key ecosystem services which should also be included in the accounts are biodiversity, flood management and water quality, although these are currently difficult to value. Peatland condition is seen as the main characteristic for the delivery of ecosystem services therefore an account based on peatland condition area is recommended. However, the lack of an agreed peat baseline map and assessment of peatland condition at the UK national level makes it difficult to incorporate peatland into the national accounts at this time.

Conclusions

This project demonstrates the value of peatland to UK society and shows that peatland restoration will have multi-benefits for a range of ecosystem services. The metrics, economic tools and protocols designed to underpin the Peatland Code have been tested and welcomed by a range of peatland restoration projects. The metrics can also be used by other government departments needing to quantify the greenhouse gas benefits of peatland restoration. The Peatland Code can utilise the multi-benefit aspect of investing in peatlands to its advantage, with the communication and promotion of these benefits key to engaging with investors.

Remote, bleak, wet peatlands can be ‘a hard sell’. Often outside the Peatland Code (by virtue of being non-additional), water companies have a commercial incentive to restore peaty water catchments in order to improve water quality and minimise treatment costs. Other companies presently have little incentive to fund peatland restoration. With a functioning carbon trading system for land-use-related carbon in the UK, full quality assurance and a higher carbon price, the Peatland Code could be the pilot for how to fund ecosystems restoration and nature conservation through carbon pricing. However, without a functioning carbon market and a significant carbon

[7] Sphagnum hummocks; not grassy tussocks or dry mosses

price, the Peatland Code will need to focus on corporate social responsibility and voluntary effort to restore peatlands. This may result in restoration being prioritised towards easily accessed and charismatic sites owned/managed by conservation agencies, NGOs, and national parks.

Recommended Next Steps for the Peatland Code

To build on this project and the Pilot phase of the Peatland Code it is recommended that:

1. As soon as data become available the metric and field protocol developed here should be expanded to include restoration of afforested bogs.
2. To complement the launch of the Peatland Code, workshops will be required to demonstrate metrics and protocol.
3. The Peatland Code would benefit from more data on the risks and on the immediacy of emissions savings through peatland restoration in comparison to woodland creation.
4. A Proof of Concept of how to integrate the Peatland Code with current agri-environment schemes will be necessary in each of the devolved administrations to reflect variations in agri-environment schemes and payment rates.
5. Peatland restoration projects need to be monitored beyond simply the initial assessment in order to verify restoration success and improvements in peatland condition over the long-term and a monitoring protocol will be required. The protocol developed here, specifically designed to calculate potential carbon savings, could be the foundation for this and would need further testing in conjunction with developments in remote sensing.

Glossary

Acrotelm	The upper, more biologically active, layer of a bog which occurs above the lowest level of the water-table.
AFOLU	Agriculture, Forestry and Other Land Uses
Assessment Unit	An area of a Project site that has been mapped using aerial photography and is of uniform condition, verified in the field and assigned to a Condition Category.
BACI	*Before–After Control-impact* design framework
BGS	British Geological Survey
Calluna	*Calluna vulgaris* (heather)
CAP	Common Agricultural Policy
Catotelm	The waterlogged (anaerobic) layer of a bog which occurs below the acrotelm.
CCA	Climate Change Agreements
CDM	Clean Development Mechanism
CM	Cropland Management
(the) Code	The Peatland Code (PC)
Condition Assessment	A survey, using the Peatland Code Assessment Unit Field Survey Form, carried out in the field to assign a Condition Category to an Assessment Unit. Three Condition Assessments are carried out in each Assessment Unit.
Condition Category	Refers to the Condition Categories assigned to a Project site developed as part of this project. These are based on the relevant academic literature on carbon emissions from peatland. The categories are: *Near Natural*, *Drained*, *Modified*, and *Actively Eroding*.
CRC	Carbon Reduction Commitment
CREW	Centre of Expertise for Waters
CSM	Common Standards Monitoring
CSR	Corporate Social Responsibility
DECC	Department of Energy & Climate Change
Defra	Department for Food, Environment & Rural Affairs
DOC	Dissolved Organic Carbon
EA	Environment Agency
ECN	Environmental Change Network
ELS	Entry Level Stewardship
EF	*Emissions Factor:* The carbon emissions derived from the literature for each Condition Category calculated as the sum of the means of all carbon flux pathways (CO_2, CH_4, N_2O, DOC, POC).

EMTF	Ecosystem Markets Task Force
ES	Ecosystem Services
EUETS	EU Emissions Trading System
EVC	Ecological Vegetation Classes
Field Protocol	Refers to the process of mapping a site using aerial images and the field survey to verify the map and assign different Condition Categories to a Project site.
FTSE	Financial Times Stock Exchange
GEST	Greenhouse gas Emission Site Types
GHG	Greenhouse Gas
GIS	Geographical Information System
GM	Grazing Land Management
Hectads	An area 10 km x 10 km square
HDC	Horticultural Development Company
HLS	Higher Level Stewardship
ICROA	International Carbon Reduction and Offset Alliance
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organisation
IUCN	International Union for Conservation of Nature
JAC	June Agricultural Census
JNCC	Joint Nature Conservation Committee
KP	Kyoto Protocol
LCM	Land Cover Map (of GB) (2007)
LBG	London Benchmarking Group
LCS88	Land Cover of Scotland (1988)
LULUCF	Land Use, Land Use Change & Forestry
MACC	Marginal Abatement Cost Curve
MENE	Monitor of Engagement with the Natural Environment
Micro-erosion	See definitions in Lindsay (2010)[8]and at Yorkshire Peat Partnership website.[9]
MMH	Mountains, moorlands and heaths
NEA	National Ecosystem Assessment (UK)
NGO	Non-Governmental Organisation
NVC	National Vegetation Classification

[8] Lindsay, R. 2010. Peatbogs and Carbon: A critical synthesis. University of East London.
[9] http://www.yppartnership.org.uk/restoration/bare-and-eroding-peat-restoration/micro-eroded-sites

OFWAT	The Water Services Regulation Authority
ONS	Office for National Statistics
OTC	Over-the-counter
PAS 2060	BSI Standard for Carbon Neutrality
PC	Peatland Code
PES	Payment for Ecosystem Services
POC	Particulate Organic Carbon
SEEA	System of Environmental-Economic Accounting
SEPA	Scottish Environment Protection Agency
SFA	Scottish Forest Alliance
SME	Small or Medium Sized Enterprise
SNH	Scottish Natural Heritage
SOP	Standard Operating Procedure
SSSI	Site of Special Scientific Interest
TGF	Trip Generating Function
UKAS	UK Accreditation Service
UNFCCC	UN Framework Convention on Climate Change
VCS	Verified Carbon Standard
WCC	Woodland Carbon Code
WDR	Wetland Drainage and Rewetting
WTA	Willingness to Accept
WTP	Willingness to Pay
WQ	Water Quality

Section 1: UK Metric for Peatland Restoration

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1.1 Summary

This chapter sets out how the project coupled greenhouse gas (GHG) emissions and peatland condition. The methodology for assessing peatland condition builds on the works of Birnie and Smyth (2013), but has been simplified following extensive field testing and integrated with the most up to date carbon flux data available (Figure 1.1).

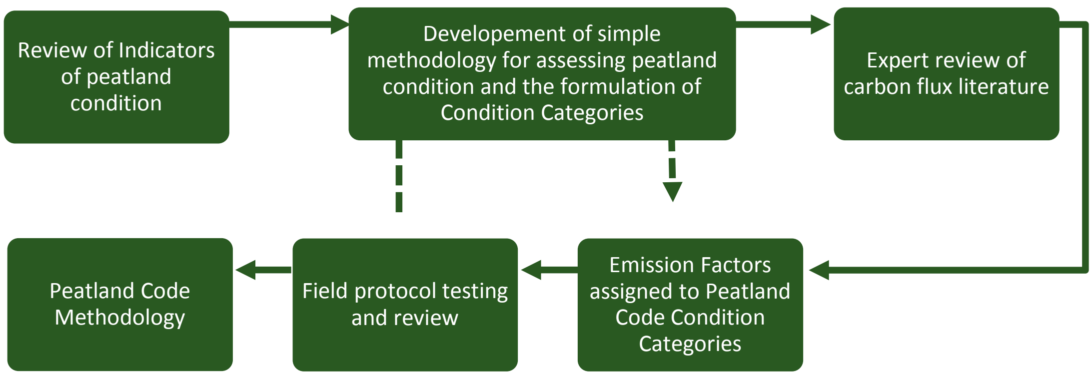

Figure 1.1 Peatland Code methodology development process

[10] IUCN Hosted Peatland Action: Learning from Success Conference (2014), 20th - 22nd October, Inverness, http://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/201410_IUCN%20Conference%20Handbook_04_WEB.pdf [Accessed on: 20/03/2015]

1.2 Assessing Peatland Condition

A number of widely used and well established methods exist for assessing peatland habitat condition already exist (Table 1.1). One significant drawback of these approaches is that they are designed for use by professionals with both good plant identification skills and field expertise. At the outset it was envisaged that the field monitoring protocol developed for the Peatland Code had to be simpler so it could be used, with the appropriate guidance, by non-experts. Employing a professional to carry out an NVC survey for example may prove too costly an undertaking for a project and negatively impact the economic viability of funding a restoration project under the Peatland Code. Another limitation of the established survey techniques is that they do not assess directly peatland habitat function. It is essential, particularly within the context of carbon, that habitat function and the features which will have an impact on carbon budgets, such as artificial drainage and extent of bare peat, be assessed.

Table 1.1 Descriptions of the most commonly used survey methods for peatlands in the UK

Survey	Objectives and Requirements
Common Standards Monitoring (CSM)	Used to inform management of sites deemed to have scientific importance and is intended to be: •A simple, quick, assessment of feature condition. •For protected sites (SAC, SPA, Ramsar, SSSI, ASSI). •Supported by limited, more detailed monitoring •botanical knowledge and experience with the NVC is essential •Conclude which condition category (for given attributes) the site meets: i)Favourable Maintained ii) Favourable Recovered iii) Favourable Declining iv) Unfavourable Recovering v) Unfavourable No Change vi) Unfavourable Declining vii) Partially Destroyed viii) Totally Destroyed
National Vegetation Classification (NVC)	Standardised approach to surveying vegetation and classifying vegetation communities which: • Not intended to be a monitoring tool • Requires very good botany and surveying skills • Acts as the main terrestrial habitat classification for: i) Guidelines for the Selection of Biological Sites of Special Scientific Interest ii) UK Common Standards Monitoring Guidance iii) UK Interpretation of Annex I habitats listed under the EC Habitats Directive iv) Detailed (Phase 2) ecological site survey and assessments
Phase I Habitat Survey	A standardised system to record and map semi-natural vegetation and other wildlife habitats and is intended to be: • Quick and relatively straightforward • Suitable for general surveys and specific habitat surveys • Helps target and inform more detailed Phase II habitat survey (NVC)

1.2.1 Previous Approach to Assessing Peatland Condition and Greenhouse Gas Emissions

Landowners and land agents in the UK will be more familiar with the Woodland Carbon Code than with the evolving draft Peatland Code, so it is very important to understand the fundamental differences between the two Codes. The Woodland Carbon Code is concerned with ***accounting for the net sequestration of carbon*** within a woodland site. It does not account for any avoided emissions because of any change in land use involved in creating the woodland, nor does it consider other possible co-benefits like biodiversity. The Peatland Code, on the other hand, is primarily concerned with ***accounting for avoided or reduced emissions from the previous land use.*** It is also concerned with other possible ecosystem co-benefits deriving from restoration such as water quality and biodiversity improvements.

The Peatland Code aims to be the **voluntary standard for peatland restoration projects in the UK** that want to be sponsored on the basis of their climate and other benefits. The Code is designed to support funding from businesses concerned with restoring damaged peat bogs primarily through Corporate Social Responsibility (CSR) interests. It **provides standards and robust science to give business supporters confidence that their financial contribution is making a measurable and verifiable difference to UK peatlands.**

A Bog Standard Way of estimating Greenhouse Gas Emissions from UK Peatlands

Peatlands are the largest store of surface carbon in the UK. This is because, unlike surface vegetation, peatlands have been accumulating carbon over thousands of years. Ensuring peatlands are in good functional condition is therefore important within the context of Greenhouse Gas (GHG) emissions from land and land use change.

Restoring degraded peatland is a natural and effective way of cutting down GHG emissions. The amount of carbon that can be saved can be significant. Repairing thousands of hectares of peat can not only provide real benefits through reduction in greenhouse gas emissions, helping us to meet our international obligations to do this, but also can save money through improved water quality and reduced flooding risk downstream.

Before starting any peatland restoration project, it is important to be able to assess the potential costs and benefits in terms of the actual GHG emissions reductions it might achieve. Because of the time and the instrumentation involved, it is **not cost-effective to directly measure losses of greenhouse gases at every potential project site.** So alternative indirect methods are required, preferably based on more **easily observed features like vegetation, and for which we can use standard values to estimate GHG emissions**.

By analysing all the available data from direct measurements of greenhouse gases over different types of peatland vegetation, research teams in continental Europe have identified what they call **Greenhouse gas Emission Site Types (GESTs)** and derived standard values for the greenhouse gas balances associated with them. They have now used these standard values for greenhouse gas balances to calculate the emission savings for a number of proposed restoration projects across a range of continental European peatland ecosystems. However, these European standard values do not include blanket bogs, which is the most common type of peatland ecosystem found in the UK.

The continental European GESTs approach has been adapted and improved for use on UK blanket bogs by a team led by the Crichton Carbon Centre in Dumfries (Birnie and Smyth, 2013). This **method used the known relationships between blanket bog ecosystem state, vegetation, physical condition and the major pathways which determine overall carbon balance**. It included carbon gains (e.g. carbon locked up or sequestrated by peatland vegetation) and carbon losses through both

chemical pathways (e.g. gaseous emissions to the atmosphere and dissolved carbon to water), and physical pathways (e.g. loss of particulate carbon through erosion by wind and water).
Five ecosystem states commonly associated with UK blanket bogs were identified. These include blanket bogs that are eroded and/or have been artificially drained. These states were described quantitatively in terms of their moisture status by using vegetation indicators (so-called "plant functional types"). All the available published measurements of GHG's in relation to these plant functional types were grouped together and analysed statistically. The analysis suggested that **there were consistent and statistically significant differences between the ecosystem states in terms of their greenhouse gas balances**. This allowed standard values for GHG balances for each of the five blanket bog ecosystem states to be estimated (Table 1.2).

Table 1.2 Descriptions of the 5 blanket bog ecosystem states/peatland condition categories provided by Birnie and Smyth (2013) and their respective impacts on the peat forming function of blanket bog ecosystem.

Ecosystem State	Peatland Condition Category[11]	Description of Impact	Impact on peat-forming function
1	**Intact**	low impact	intact
2	**Moderately Degraded**	moderate impact	reduced
3	**Highly Degraded**	heavy impact	lost
4	**Eroded**	severe impact	lost and peat mass itself is being destroyed
5	**Artificially Drained**	presence of artificial drainage channels typically @15-20m apart	reduced and possibly lost altogether

[11] It is important to note that the word "*degraded*" is often seen as pejorative by land managers. Here it is used in the context of the provision of ecosystem services to indicate the effect of land management on peat-forming ecosystem function. The peatland may still perform other ecosystem functions which provide benefits.

1.2.2 Developing the Approach to Assessing Peatland Code Condition Categories

To further develop the Condition Categories for the Peatland Code it was necessary to provide more precise definitions for the 5 blanket bog condition categories (or ecosystem states) identified by Birnie and Smyth (2013). These definitions use readily observed features, either from aerial photography or through reconnaissance field survey, and provide the practical link between field assessments of peatland condition and the estimation of GHG emissions from any blanket bog site in the UK. They also provide the foundation for subsequent monitoring of any peatland restoration project.

Because the original (Birnie and Smyth 2013) peatland condition categories were devised so as to capture the impacts of differing intensities of land management (e.g. burning, trampling, grazing) on peat-forming function of the peatland ecosystems, it is logical to define them more precisely using the impact indicators available from existing published guidance, specifically that from SNH used for surveying land management impacts in upland habitats (MacDonald *et al.,* 1998). This approach has several obvious advantages. Firstly, the SNH guidance is in the public domain and is intended for practical use by people with a general rather than a specific knowledge of vegetation, such as might be involved in peatland restoration projects. Secondly, the guidance is based upon impact indicators which are clearly and comprehensively defined, including both large-scale and small-scale indicators. Thirdly, the systematic methodology provided can be used for both baseline assessment and subsequent monitoring of peatland restoration projects.

MacDonald *et al.,* (1998) propose two levels of indicators: large-scale and small scale. Because of the practical considerations relating to cost-efficiency of surveys involving the use of small-scale indicators of impact (these require fairly intensive field programmes to operate), we confine our definitions to the use of the large-scale indicators of impact. MacDonald *et al.,* (1998) describe these as follows:

"…….the large-scale indicators are meant to be used from some distance away from the assessment unit, generally at distances between 100m and 1km. Some do require closer inspection of small areas but the results of this inspection indicate conditions over a much larger area" (Volume 2, p.15).

We would add that some can be identified by air photo interpretation. MacDonald *et al.,* (1998) identify 17 Large Scale Indicators of land management impacts on blanket bog habitats. These indicators are grouped into sets related to the three main types of impact: a) drying and peat loss; b) burning; c) trampling and grazing. These indicator sets and the way that we propose to use a selection of them, are described in more detail in the following section.

1.2.2.1 Consideration of indicators of peatland condition

a) Drying and peat loss (Table 1.3)

In the SNH guidance, the set of indicators which point to drying and peat loss include two which relate to artificial drainage (spacing and depth). Because we have chosen to identify artificially drained blanket bog as a separate condition category, dealt with in a later section, these are not included here as indicators of drying and peat loss. We therefore suggest three indicators in this set as follows:

1. Presence of an irregular patterning of sphagnum moss hummocks (each up to several m^2 in size) producing a gently undulating surface.
2. Extent of bare peat.
3. Extent of *Calluna vulgaris, Molinia caerulea,* scrub (e.g. birch on lowland raised bogs)

Table 1.3 Indicators of drying and peat loss

Indicator	Low impact Lightly dried/disturbed	Moderate impact Moderately dried/disturbed	High impact Heavily dried/disturbed
1. Presence of an irregular patterning of sphagnum moss hummocks	Conspicuously and predominantly hummocky	Hummocky in parts	Not obviously hummocky
2. Extent of bare peat	Most of assessment unit well vegetated with little peat exposed	Bare peat showing through a thin vegetation cover over limited areas (<100m^2) or completely bare peat in small, sparse patches	Bare peat showing through a thin vegetation cover over extensive areas (>several 100m^2), or completely bare peat in large and/or multiple patches(individual patch size <2m^2) dispersed over the majority of the assessment unit. NOTE Extensive bare peat with gullies is defined as SEVERELY DEGRADED AND ERODED
3. Cover of Calluna vulgaris, Molinia caerulea, scrub	Absent or very scattered. Any denser patches are non-linear	Scattered patches, mostly on higher ridges?	Conspicuous and extensive over most of the assessment unit.

b) **Burning** (Table 1.4)

The SNH guidance identifies two sets of indicators relating to burning intensity and frequency respectively. On the basis of further field experience, and to reduce subjectivity (e.g. judgements about colour) and criticality of timing of field visits (relative to how recent burning events are), these have been combined and re-defined here. A modified set is proposed which comprises 5 indicators of burning, two of which may be determined primarily by air photo interpretation (marked by *):

4. Extent of bare peat in the burnt patch.
5. Pattern of burning.
6. Degree of difference between vegetation of unburnt and burnt bog.
7. Occurrence of extensive (100’s m2) dark brown, black, grey, greyish green, dark green or bright yellow-green crusts or carpets of lichens, algae, or mosses.
8. Intensity of long term fire regime.

Table 1.4 Indicators of drying and peat loss

Indicator	Low Impact (lightly burnt)	Moderate Impact (moderately burnt)	High Impact (heavily burnt)
4. *Extent of bare peat in the burnt patch (use binoculars and air photography to identify burnt areas).	Little or no bare peat	Little or no bare peat	Bare peat showing through a thin cover of live or dead plant material over most of the burnt area, and/or completely bare peat in several patches (individual patch size >2m^2)
5. Pattern of burning.	Very irregular with many patches remaining unburnt even on baulks and ridges	Ridges uniformly burnt but hollows missed or lightly singed	Uniform. No unburnt patches even in hollows
6. Degree of difference between vegetation of unburnt and burnt bog (look across fire line)	Little difference, similar vegetation composition on both side of fire line	Noticeably fewer patches of heather and shrubs in the burnt area when compared to unburnt area, “grassy” areas could be more extensive	Burnt area dramatically different and may be patchy and irregular with some trees and shrubs, “grassy” patches, and patches of mosses and lichens as well as dwarf shrubs
7. Occurrence of extensive (100’s m^2) dark brown, black, grey, greyish green, dark green or bright yellow-green crusts or carpets of lichens, algae, or mosses. Mosses likely to be Racomitrium lanuginosum or “bottle-brush” mosses (Polytrichum spp. or Campylopus spp.).	Absent or very scarce	Infrequent small, scattered patches (<0.5m across) or small tufts mixed with *Sphagnum*	Conspicuous, widespread
8. *Intensity of long term fire regime (assessed from air photography)	No or very limited evidence that there are burnt patches, if there are they are not frequently distributed across the site (they have been isolated events)	A small number of burnt patches evident, more frequently distributed across the site (more likely they have been intentionally located)	Many burnt patches across the site evident, some patches crossed over by other fires, patches at obviously different stages of vegetation recovery (suggesting frequent burning across whole site)

c) Trampling and grazing (Table 1.5)

MacDonald *et al.,* (1998) identify 5 indicators that relate to trampling and grazing impacts only 4 of which are suggested for use here:

9. Bare peat exposed by trampling, wallowing and rubbing by livestock and deer.
10. Extent of sheep, deer or cattle paths.
11. Amount of flowering of *Eriophorum* spp.
12. Luxuriance of Sphagnum, dwarf-shrubs, and sedges on very small islands (<1-2m^2) in permanent bog pools, <2m from the bank, relative to the surrounding bog surface.

Table 1.5 Indicators of trampling and grazing impacts

Indicator	Low impact Lightly trampled/grazed	Moderate impact Moderately trampled/grazed	High impact Heavily trampled/grazed
9. Bare peat exposed by trampling, wallowing and rubbing by livestock and deer.	Very scarce or absent, or if present then erosion inactive and ground re-vegetating	Localised and infrequent. Little or no active erosion	Frequent and conspicuous, perhaps actively eroding
10. Extent of sheep, deer or cattle paths.	Absent, or occasional single paths showing little branching	Conspicuous, but very localised, mostly restricted to dry ridges or fencelines	Extensive and conspicuous, ramifying over most of the bog surface
11. Amount of flowering of Eriophorum spp.	Widespread and abundant. Very conspicuous	Patchily abundant, or widespread but thinly scattered	Little or none. Inconspicuous
12. Luxuriance of Sphagnum, dwarf-shrubs, and sedges on very small islands (<1-2m²) in permanent bog pools, <2m from the bank, relative to the surrounding bog surface.	No difference	Island>surrounding bog	Island>surrounding bog

1.2.2.2 Categories of Eroded Blanket Bogs

The indicator sets presented in the previous section provided the means for separating blanket bog into three impact categories. However, the remaining two blanket bog ecosystem categories, *Drained* and *Actively Eroding*, which are physically degraded either by natural erosional processes (e.g. water, wind, frost etc.) or mechanical disturbance by land managers (e.g. artificial draining, peat cutting etc.) appear to be associated universally with net negative GHG balances, with annual emission losses potentially an order of magnitude greater than the annual gains on intact blanket bog surfaces. So whilst units of these categories may occupy a relatively small proportion of any potential restoration site they may have a disproportionate impact of the overall GHG balance for that site. It is therefore important to identify them as precisely as possible. This section provides a set of the potential indictors, partly based on the SNH Guidance, especially as regards drained sites but also includes further field experience of the present authors more closely related to the factors determining GHG balance.

The area of exposed bare peat is considered as the key determinant in driving carbon losses from physically degraded blanket bog, by providing both a reactive surface for direct oxidation and gaseous emission, and a source for losses of organic carbon in dissolved (DOC) and particulate (POC) forms. So it is logical to use the "extent of bare peat" surface as an impact indicator for both eroding and artificially drained categories. Whilst this is also used as an indicator of drying and peat loss (Table 1.3) it is recognised that there is a transition from highly impacted but intact peatland surfaces (in terms of near-complete vegetation cover) to severely degraded and eroded ones. However, it is generally recognised that it is possible both to identify and measure the planimetric area of bare peat surfaces using aerial photography. Orthorectified aerial photography (i.e. geometrically rectified to fit the OS grid) at scales of around 1:10,000 is widely available for most if not all of the UK via mapping systems like Google Earth Pro (Google Inc., 2013). These systems also provide basic GIS measurement functions which can be used to provide quantitative estimates of bare ground. An example of this type of mapping is given in Figure 1.2.

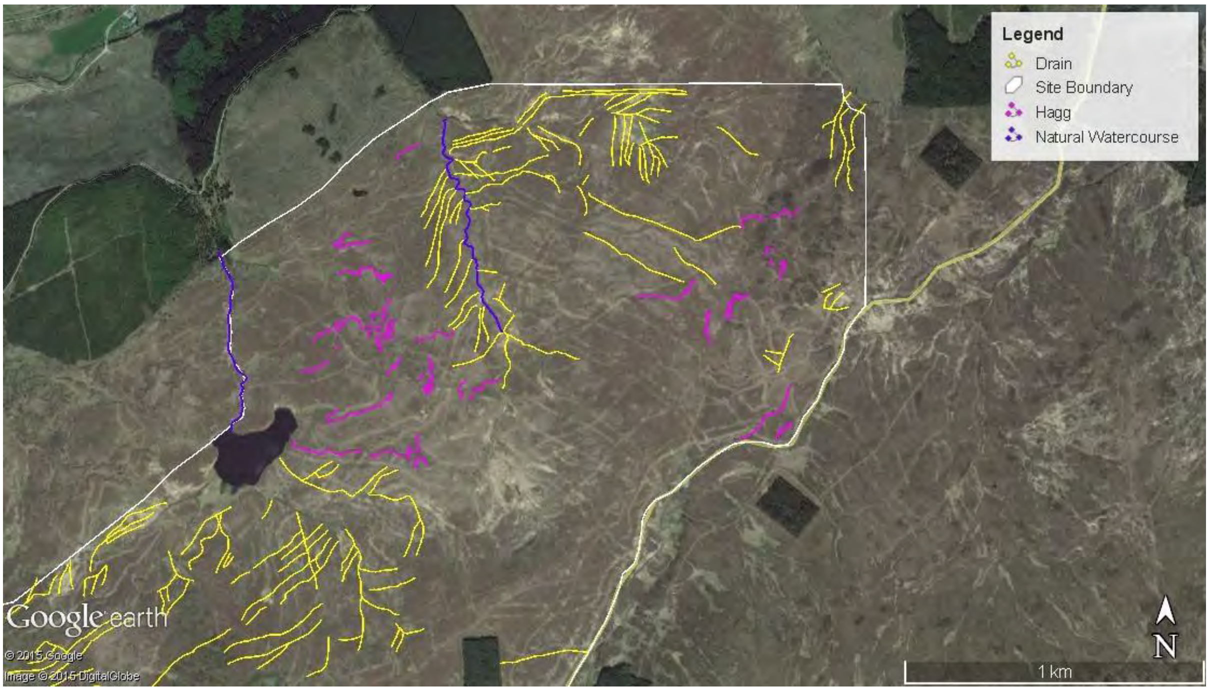

Figure 1.2 Air photo interpretation of erosion gullies and mechanically-cut drains (grips) on a blanket bog site in south Scotland.

Severely degraded and eroded blanket bog is often described as being “hagged” or “gullied” (see for example Penny Anderson Associates, (2012). A full description of the geomorphology of blanket peat is given by Evans and Warburton (2007) but their differentiation of eroded peatland generally follows the simple two-type classification originally proposed by Bowers (1960). This differentiates between Type I, the complex jigsaw-type interconnecting gullying typical of hagged peats, often associated with peat flats (bare peat) and commonly found in valleys and on interfleuves, and Type II, generally parallel gullies more found commonly on valley sides (Figure 1.3).

Both Types of erosion gully system are associated with extensive bare peat surfaces when they are actively eroding (Figure 1.4). Because of the more complex geometry of their gully systems, the areas of bare peat tend to be greater with the hagged type (Type 1). Interpreting both Types in assessing peatland condition for the Code will involve the mapping of the areas, as a line in the case of a gully system (see example given in Figure 1.2) and as a polygon in the case of an area of larger expanses of bare peat. Both mapped features will be mapped with a 30m buffer zone, as with the *Drained* Condition Category (see Box 1.1), to reflect that these erosion features will have a drawdown effect on the water table in the surrounding area.

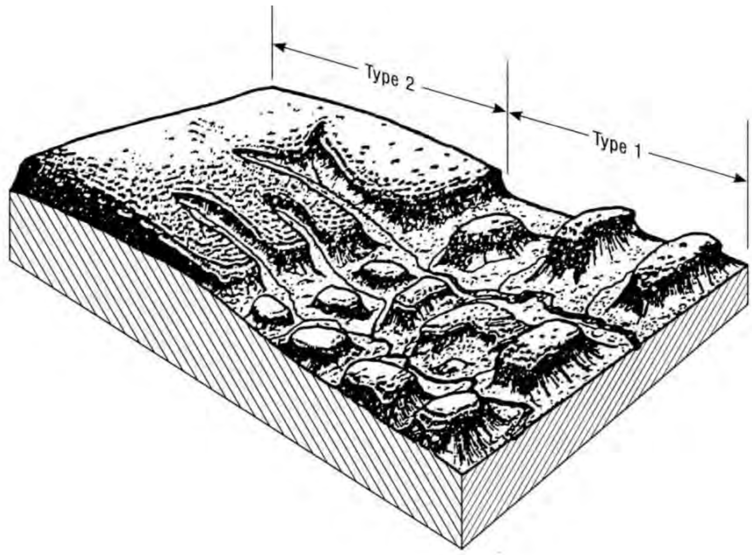

Figure 1.3 Main types of gully erosion found in blanket peats (after Bower, 1961). Type 1 is commonly found in flat or gently sloping areas and comprises a series of gully systems that have cut into the peat to create a series of isolated blocks or peat hags. This is sometimes also called jigsaw erosion. Type 2 is found on slopes and the gullies generally run parallel to each other with headward extension into branches. Both types can have gullies that are entirely cut within the peat mass or extend downwards into the mineral substrate.

Figure 1.4 Erosion gully in blanket peat at Alladale Estate site in East Sutherland. Gully sides are near vertical and in some places overhanging. Re-vegetation of the gully floors tends to occur only after the full depth of the peat has been lost.

1.2.2.3 Categories of Artificially Drained Blanket Bogs

Penny Anderson Associates (2012) suggest that artificially drained peatland is generally easy to detect on aerial photographs, the individual drains appearing as parallel lines often herring-boned together at their downstream ends (Figure 1.2). But they also note that their visibility depends on a number of factors including whether the vegetation has been recently burnt, the depth and width of the drains and the presence of water in them. In our experience, drains are often indirectly picked out by the vegetation on the drier spoil ridges alongside them (often *Calluna*).

MacDonald *et al.,* (1998) use both spacing and depth as indicators of impact of artificial drains. From our experience drain depths have to be measured in the field and also tend to be relatively constant at around 0.5-0.6m so for these reasons depth is not used as an indicator here. The pattern or density of drainage is relatively easier to observe. Again from field experience, there tends to be 3 types of drainage system: one where grips have been cut at very wide spacings and sometimes almost at random; one where grips have been cut on a regular basis often around 20-25m apart and lastly, a few situations where there appear to have been multiple phases of draining, often with drain lines cutting across each other to form a reticulate pattern of drains. In all cases there are examples of where the drain lines have formed the focus for the further development of erosion gullies.

Following the review by Lindsay (2010) and others research on the extent of the hydrological impacts of surface drains on blanket bog vegetation and microtopography, we propose a procedure of mapping the drain lines on the air photos and then using a 30m buffer (See Box 1.1) either side of them to estimate the area affected by them. This procedure generally follows the "dry shadow" approach proposed by Paul Leadbitter (pers. comm.) of the North Pennines AONB. This approach conforms with the procedure adopted by Penny Anderson Associates (2012) in relation to their mapping of "gripped" peatland from air photos, done on behalf of Natural England.

Box 1.1 Drains: estimating the extent of effect

After considerable discussion and field testing we have developed the protocol to consider 30m around an artificially cut drain as being the area effected by the drain. On blanket bog sites field observations suggest that drains are most often cut 25 to 30m apart (although at intensively managed sites they may be closer) which indicates that in order to effectively drain a site land owners and managers have cut the drains at points where the last drain cut will lose effect. This field evidence we feel is the strongest practical indicator of the area of effect of an artificially cut drain. However this scenario relates to the most common ~50cm wide ~50cm deep drains on blanket bog. We fully accept the area affected could be higher around, for instance, the much larger “canal” type drains cut across raised bog. We recommend that a project could, with sufficient evidence (e.g. strong changes in vegetation composition, hydrological monitoring) argue for a larger area with verification by the Peatland Code.

1.2.3 Peatland Code Condition Categories: Summary

Using the indicators described above the appropriate peatland Condition Category for a given area of bog can be established (Table 1.6). There are no absolute allocation rules and not all indicators will be applicable at all sites or within any one site. MacDonald *et al.,* (1998) suggest the use of as many indicators as possible and not rely on just one or two. They also suggest that *the decision on the overall impact class for an assessment unit should be based upon the average of the class results for all the indicators used*.

Table 1. 6 Peatland Code Condition Category criteria to be used, following extensive field testing, to determine condition of a site using the Field Survey Protocol. Key criteria for each category in italics.

Peatland Code Condition Category	Description
Pristine	• Dominated by peat forming species (in most instances *Sphagnum* moss) • Never been modified by landuse: drainage, grazing, burning, pollution
Near Natural	• *Sphagnum dominated* • No known fires • Grazing and trampling impacts scare or absent • Little or no bare peat • *Calluna vulgaris* absent or scarce
Modified	This category can be split into two further categories (which will help to inform management/restoration plan) although both will have the same *Modified* emissions factor. <u>Moderately degraded</u> • Infrequent fires • *Grazing and trampling impacts localised and infrequent* • *Sphagnum in parts* • Extent of bare peat limited to small patches • Scattered patches of Calluna vulgaris <u>Highly Degraded</u> • *Small discrete patches of bare peat frequent (micro-erosion)* • Frequent fires • Frequent and conspicuous impacts of grazing/trampling • *No/little Sphagnum* • Calluna vulgaris extensive
Drained	Within 30m of an artificial drain (grip)
Actively Eroding	• Actively eroding hagg/gully system (*most of their length having no vegetation in gully bottoms with steep bare peat "cliffs")* • Extensive *continuous* bare peat (eg. peat pan) • Extensive bare peat at former *peat cutting site*

1.2.4 Peatland Code Condition Categories: Field Protocol

The field protocol for assessing the condition of a Project site and estimating GHG balance has 4 key stages:

1. Desk based assessment of aerial images of the site
2. Field survey, using Field Survey Tick Sheet
3. Confirmation of site condition(s)
4. Calculating Emissions Savings

As the Field protocol was made available to external organisations a Users' Guide was produced: "Assessing the Condition of your Project Site: Guidance and Procedures", which can be found in Annex 1. The Users' Guide provides worked examples and photographs to help users through each of the four stages. The objectives of each of the four stages of the protocol are summarised below.

1.2.4.1 Desk Based Assessment of Aerial Images

The purpose of the desk based assessment of aerial photography is to start to identify the condition(s) of the peatlands at a potential Project site. By assessing the site using aerial photography a site can be mapped into different units (Assessment Units): those which look to fit one of the four Condition Categories and those areas which are clearly not peatland and not eligible for the Peatland Code (for example rocky outcrops, water bodies etc.). This information forms the basis for the field survey as each individual Assessment Unit identified will be surveyed in the field to assess/confirm its condition.

1.2.4.2 Field Survey

A project site will always have to be surveyed in the field to confidently determine which Condition Categories the peatland areas belong to. The Assessment Unit map, described in the previous section, provides the structure for the field survey, which has been designed to assess a site using easily identifiable field indicators.

Each Assessment Unit to be included in a Peatland Code Project has to be visited in the field to firstly determine that the unit is eligible for Code by meeting 40cm minimum peat depth criterion, and secondly to determine the Condition Category. The field survey will also help determine the Condition Category the Assessment Unit will become through restoration. The field survey consists of a simple, two page, tick sheet, and although effective in assessing condition, it is not designed to prescribe the necessary restoration measures. The tick sheet was developed using the indicators described in Section 1.2.1, however, through extensive field testing indicators were refined and simplified to ensure the survey can be carried out at any (upland/lowland blanket/raised bog) site irrespective of the time of year providing the ground is visible (i.e. not snow-covered). Some aspects of the survey, particularly grazing and burning impacts, will benefit from information gathering prior to field survey.

The Field Survey tick sheet, and accompanying Guidance, can be found as Annex 2 to this report.

1.2.4.3 Confirmation of Site Condition

After undertaking three individual Condition Assessments in the field within each of the Assessment Units each Unit can be allocated to the appropriate Condition Category. This Condition Category represents the current state (i.e. the time of the survey) of the Assessment Unit.

1.2.4.4 Calculating Emission Savings

The purpose of calculating emissions savings brought about by the peatland restoration activities undertaken by a Peatland Code Project is to estimate the income that can be generated by selling the associated carbon credits on the carbon market. Once each Assessment Unit has been ascribed a Condition Category the emissions savings for a project, given as tonnes of CO_2 equivalents per hectare per year ($tCO_2eq/ha/yr$), can be calculated from the change in Condition Categories for each Assessment Area.

To help a project calculate emission savings an Excel worksheet is included in the "The Peatland Code Project Financial Feasibility Tool" (See Section 2, Appendix 2.3).

1.2.5 Testing of the Field Protocol

Throughout its development the Field Protocol and Field Survey Tick Sheet were tested at various different bogs across the UK (Appendix 1.1). This included bogs in each of the Condition Categories, lowland raised bogs and upland sites, those which have seen some restoration and those which have yet to be restored. Although the protocol was initially developed for blanket bogs, it was also tested and amended in the later stages of development to make sure it was also applicable to lowland raised bogs. The Protocol was also presented at the IUCN "Peatland Action: Learning from Success" Conference[12] where delegates attending the Peatland Code Pilot Project workshop were given an opportunity to review and respond to the Condition Categories and their field criteria. Reponses were very positive with the key messages from the workshop session being:

- A general agreement with the 4 condition categories
- Agreement that the 4 categories easily identifiable in the field
- General agreement with the field indicators of the 4 categories
- That the impact of restoration will be site specific and dependent on starting point (making it necessary for Peatland Code to verify estimated Condition change and GHG savings)
- Uniformity of vegetation an indication that site has been modified (worked into Field Protocol Guidance

1.3 Emission Factors

1.3.1 Data Review

A full review was undertaken of the published peer-reviewed literature used to derive the emission factors for each of the Condition Categories. Although Emission Factors were given by Birnie and Smyth (2013) this new review ensured the most up to date research was included and that Emission Factors were integrated with the Condition Categories which were identifiable in the field using the simple Field Protocol described above. The review process is described in Figure 1.5.

[12] IUCN Hosted Peatland Action: Learning from Success Conference (2014), 20th - 22nd October, Inverness, http://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/201410_IUCN%20Conference%20Handbook_04_WEB.pdf [Accessed on: 20/03/2015]

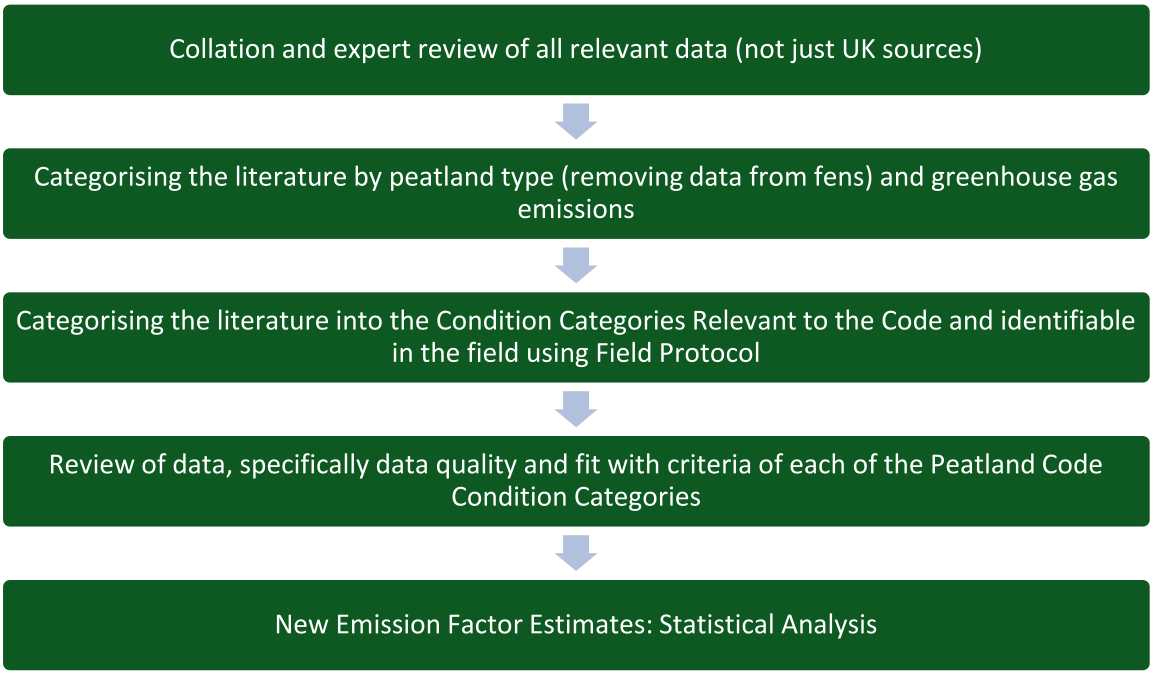

Figure 1.5 Data review process[13].

1.3.2 Statistical Analysis

The final dataset was subjected to statistical analysis using residual maximum likelihood to calculate the average emission factors and 95% confidence intervals for each of the condition categories. The analysis took various factors into account. For example, GHG fluxes may have been measured on the same site for a number of years, in which case a simple average of a site with multiple years of measurements would be part of the same dataset as a number of other sites that may only have a single year's measurement. As the multiple data from the same site are likely to be more similar than individual data from other sites, we accounted for any multiannual measurements within a given site in the coded design. As the climate in identical years between different sites would be expected to also result in more similar emissions (i.e. GHGs measured in 2003 in two different sites might be reasonably expected to result in more similar emissions than those from two sites measured in 1999 and 2007, respectively), the year of monitoring was also taken into account. In many of the condition categories, we also had occurrences of data where GHG emissions had been measured at a single geographical location but using different experimental treatments or plots of differing vegetation or landscape characteristics. To ensure that no bias was introduced when comparing such data were analysed alongside single site estimates, *site* was used as the highest factor in the hierarchy, with any experimental plots coded as nested within site.

The final dataset was quite limited in terms of the data deemed relevant to the UK situation, with many of the GHG pools showing insufficient data for a statistically robust estimation of the likely flux. Table 1.7 shows the breakdown of the data by number of sites, nested treatments or plots within site, and finally the number of years over which annual budgets were measured. The wide ranges of the emissions associated with each of the condition categories are illustrated in Figure 1.6.

[13] It is anticipated that more thorough account of the data review process and statistical analysis will be published separately in due course.

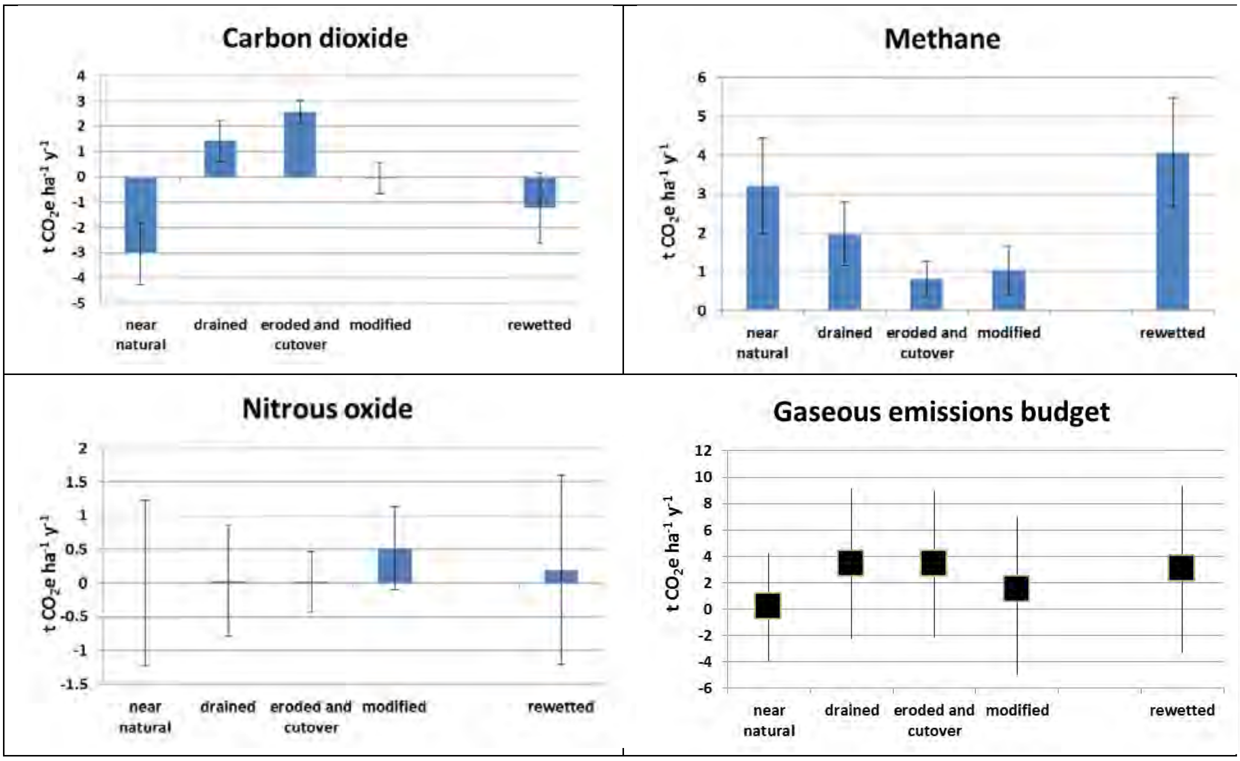

Figure 1.6 GHG emissions from UK blanket bogs.

All condition categories with the exception of *Near Natural* sites are, on average, net CO_2 sources, with very few studies indicating net CO_2 sequestration in disturbed peatlands. All of the *Near Natural* sites are net CO_2 sequestering. This net uptake of carbon dioxide is partially offset by methane emissions. In near-natural sites, the average methane emissions appear to be large enough to cancel out the average carbon dioxide uptake. However, it is worth bearing in mind that this would not be a valid conclusion to make, as a partially different set of sites, years, and treatments contribute to the calculated average methane emissions than for the carbon dioxide averages. Ideally, full carbon budgets should be compiled at the individual site level and then combined at the condition category level. However, this is not feasible at present as many studies only focus on a single greenhouse gas. The available data for nitrous oxide fluxes are particularly scarce and we conclude that the emissions averages across all assessed condition categories are not robust enough to include in formal carbon accreditation. Most of the data contributing to averages above zero (most notably in the modified – and rewetted condition categories) originate from non-UK studies, where the site has similar vegetation and climatic conditions to UK blanket bogs, but these sites generally have a history of increased nutrient inputs (see notes to Table 1.7). Hence, we suggest that emissions from nitrous oxide fluxes should be estimated at zero, until further UK data become available.

Table 1.7 Summary of the number of data points included in UK blanket bog emission factor calculations, including breakdown of nested factors. * non-UK study only, with history of peat cutting and possibly fertilisation. ** Lack of data forced aggregation of the eroded and bare, cutover categories into the *Actively Eroding* Peatland Code Condition Category, however there are indications that these should be separated once additional data become available

Condition Category	CO_2	CH_4	N_2O
Near natural	**20** (5 sites; 1-5 microsites, 1-9 years)	**20** (8 sites; 1-5 microsites, 1-6 years)	**3** (2 sites; 1 microsite, 1-2 years)
Drained	**15** (4 sites; 1-2 microsites; 1-8 years)	**30** (8 sites; 1-7 microsites; 1-6 years)	**20** (6 sites; 1-3 microsites; 1-5 years)
Modified	**39** (9 sites; 1-6 microsites; 1-4 years)	**29** (6 sites; 1-6 microsites; 1-3 years)	**2*** (1 site, 2 microsites, 1 year)
Eroded or bare cutover*	**16** (3 sites; 1-6 microsites; 1-3 years)	**10** (5 sites, 1 microsite; 1-4 years)	**7** (2 sites; 1 microsite; 3-4 years)
Rewetted	**63** (12 sites; 1-4 microsites; 1-5 years)	**46** (11 sites; 1-4 microsites; 1-5 years)	**30** (6 sites; 1-4 microsites; 1-5 years)

We also reviewed the available data for rewetted sites. *We caution against using these values for carbon accounting from rewetting projects, because the vast majority of data originate from restoration sites where monitoring took place within 5 years of the restoration/rewetting works.* Such projects are generally too immature in terms of the recovery of the site vegetation composition and hydrology, and hence GHG emissions can fluctuate highly between different years. This would need to be taken into account by using the age of the site since restoration as an additional factor in the statistical analysis, however there is as yet insufficient data to calculate robust emissions estimates from rewetted sites in such a manner. In summary, there appears to be some abatement potential from the restoration of degraded peatlands, on average, however the extremely high variability of GHG flux measurements suggests that the ranges overlap at least partially. Future assessments would ideally be based on a meta-analysis of the emissions observed in experiments using a BACI design (before-and-after; control-intervention), instead of bulking data from observations grouped by site condition.

1.3.3 Condition Categories

To marry the emission factors with the simple Field Protocol developed another review of the database of source literature was carried out specifically with the task of assigning the sites described in the database to one of the defined Condition Categories. The literature was assigned to one of the Peatland Code Condition Categories by assessing the description of sites given in the papers as well as additional relevant information on the sites (e.g. personal knowledge of the sites, peer reviewed papers on vegetation composition). It was apparent that more detailed Condition Categories (for example Highly Degraded/Moderately Degraded *Modified* Condition Category) were not supported by the literature meaning that "clumping" of the Condition Categories was needed to ensure each category could be backed up with actual emissions data.

These changes meant that the *Highly Degraded* and *Moderately Degraded* categories had to be clumped into a *Modified* category and that *Actively Eroding* (described initially as Severely Eroded) included data from both cut-over sites and one actively eroding hagg system (Bleaklow, Peak District) as there were not enough data points to separate these out. The criteria for each of the Condition Categories are given in Table 1.6. This ultimately resulted the set of four and distinct Condition Categories which could be assigned an Emission Factor while also being identifiable in the field using the field protocol.

1.3.4 Summary and Descriptive Statistics

Four Condition Categories: *Near Natural*, *Modified*, *Drained* and *Actively Eroding* can be assigned an Emissions Factor following the data review and statistical analysis (Table 1.8). The "Pristine" category (Table 1.6) cannot be assigned an Emissions factor at this time due to a lack of data. However, when assessing the impact of a restoration project on Condition and GHG emissions a site will never return to a pristine state, as defined by the criteria presented by us here, as it has been modified in some way. However, the impact of restoration on GHG emissions can be calculated for a given change between Condition Categories (Table 1.9). Being able to predict the expected vegetation and hydrological changes (from field data) provides confidence as to whether the restoration will result in *Near Natural* or *Modified* condition over the project timescale. The Field Protocol default is that an *Actively Eroding* system will be unlikely to return to a *Near Natural* system because of the modified hydrology.

Table 1. 8 Emission Factors for each Condition Category after statistical analysis ($tCO_2eq/ha/yr$) using IPCC default values for DOC and relevant literature for POC. Table 1.9 gives net effect of restoration activities which change condition. See footnotes for details on how POC and DOC values were derived. *Not enough UK appropriate data from pristine sites exists to give an Emissions Factor.

Peatland Code Condition Category	Descriptive Statistic	CH_4	CO_2	N_2O	DOC	POC	Emission Factor
Pristine*	-	-	-	-	-	-	**Unknown**
Near Natural	Mean (±StE)	3.2(1.2)	-3.0(0.7)	0.00(0.0)	0.88[14]	0	**1.08**
	Median	1.5	-2.3	0.0			
Modified	Mean (±StE)	1.0(0.6)	-0.1(2.3)	0.5(0.3)	1.14[15]	0	**2.54**
	Median	0.2	0.1	0.5			
Drained	Mean (±StE)	2.0(0.8)	1.4(1.8)	0.00(0.00)	1.14[16]	0	**4.54**
	Median	1.0	-0.9	0.0			
Actively Eroding	Mean (±StE)	0.8(0.4)	2.6(2.0)	0.0(0.0)	1.14[17]	19.3 (average of 14.67[18] and 23.94[19])	**23.84**
	Median	0.1	0.4	0.0			

Table 1. 9 Net effect on GHG emissions resulting from restoration and changing Condition Categories calculated using the Emission Factors given in Table 2. Units are t CO_2 eq/ha/yr.

Condition Category Change	Net Effect ($tCO_2eq/ha/yr$)
Restoring from Modified to Near Natural	Saves 1.46
Restoring from Drained to Near Natural	Saves 3.46
Restoring from Drained to Modified	Saves 2.00
Restoring Actively Eroding to Modified	Saves 21.30
Restoring Actively Eroding to Drained	Saves 19.30
Allowing Drained to develop into Actively Eroding	Loses 19.30

[14] Calculated as the mean value of reported values in UK studies given in Table 2A.2 of the 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement) http://www.ipcc-nggip.iges.or.jp/home/wetlands.html

[15] IPCC Tier 1 default value for drained peatland (best estimate for modified condition)

[16] IPCC Tier 1 default value

[17] IPCC Tier 1 default value for drained peatland (best estimated for actively eroding condition)

[18] Estimated from UK blanket bogs (in Goulsbra, C., Evans, M. & Allott, T. (2013) Towards the estimation of CO_2 emissions associated with POC fluxes from drained and eroding peatlands. In: Emissions of greenhouse gases associated with peatland drainage waters. Report to Defra under project SP1205: Greenhouse gas emissions associated with non-gaseous losses of carbon from peatlands – fate of particulate and dissolved carbon. Report to the Department of Environment, Food and Rural Affairs, UK)

[19] Value from Birnie and Smyth (2013) unpublished, but recalculated to reflect that 70% of POC derived carbon assumed to be reaching the atmosphere with remaining 30% assumed redeposited (Chris Evans *pers. comm*).

1.4 Future Work to Support the Code

It is suggested that four topics would benefit from further work as follows:

1) Emission Factors

It is anticipated that more GHG data will continue to be made available in the future. Therefore the Emission Factors presented here should be viewed as best estimates at this time. Specifically it is hoped that more data from *Pristine* sites will become available so this category can be assigned an Emissions Factor. In addition, with more data, it is anticipated that the *Near Natural* category Emissions Factor may become lower. It is therefore recommended that Emissions Factors be reviewed as the Peatland Code developed.

2) Forestry and Bogs

This project did not estimate an Emission Factor for afforested bogs or forest-to-bog restoration scenarios, again due to lack of data. However, in light of the work that is currently being undertaken, particularly in the Flow Country, it will be possible in the future to include forestry.

3) Estimated Area of Rewetting

This project estimates the area affected by an artificial drain, and the subsequent area that will be rewetted with restoration, as 30m which is based on field observations. To increase the robustness of this estimate further field measurements require to be made at a range of sites to encompass different site types and conditions.

4) Field Protocol Development

Throughout the duration of this project considerable effort was made in testing the field protocol at as many different sites across the country as possible, with as many different people as possible, to ensure it was appropriate for us across the UK. To further its development, and ensure the guidance on the field protocol is sufficient, it would be beneficial to trial its use at a series of workshops, or through one-to-one meetings with any future Peatland Code Pilot Projects.

1.5 References

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Appendix 1.1 Field Protocol Development: Field Testing

Table A Sites where Field Survey Protocol was tested in the field

Site	Location	Condition Categories
Cairnsmore of Fleet	Dumfries and Galloway	Modified, Drained
Eldrick Hill	Ayrshire	Drained
Ben Lomond	Loch Lomond	Drained
Kinmount Buckbarrow	Lake District	Drained, Actively Eroding (pre-restoration)
Armboth Fell	Lake District	Modified
Shap and Mosedale Fell	Cumbria	Drained, Actively Eroding (pre-restoration)
North Pennines	North Pennines	Drained, Actively Eroding
Upland site, South Lanarkshire	South Lanarkshire	Modified
Upland site, South Lanarkshire	South Lanarkshire	Actively Eroding
Ysbyty Estate	Wales	Modified
Glaslyn	Wales	Drained, Modified
Forsinard	Sutherland	Near Natural
Carsegowan Moss	Dumfries and Galloway	Near Natural
Kirkconnell Flow	Dumfries and Galloway	Drained
Racks Moss	Dumfries and Galloway	Modified
Bartaggart Moss	Dumfries and Galloway	Near Natural, Drained
Waskerley	North Pennines	Drained, Actively Eroding, Modified
Rockhope	North Pennines	Actively Eroding, Modified
Talla Moss	Scottish Borders	Drained, Modified
Little Firthope	Scottish Borders	Actively Eroding
Rotten Bottom	Scottish Borders	Actively Eroding, Drained
High Moss	Peak District	Actively Eroding

Less formal testing conducted at: Silver Flowe (Dumfries and Galloway), Flanders Moss (Stirlingshire),

Additional input gratefully received from: Shona Carver (Scottish Water), Stephen Corcoran (Cairngorms National Park Authority), Wendy Fenton (FH Land Management), Sue White (Peatland Action, Shetland)

Table B Survey details and subsequent development of the protocol

Site & Survey Details	Amendments to Field Protocol Key Findings
Cairnsmore of Fleet NNR, Dumfries and Galloway Surveyed by CCC Areas where field protocol was tested: drained areas, Molinia dominated areas, area of more intact raised bog	Recommend that another tick box is given for burning indicator in Q5 for when fire history is not known. This would ensure that when history not known the indicator is not included in the tick count at the bottom of Q5.
Eldrick Hill, Dumfries and Galloway Surveyed by CCC Site is owned by Forestry Commission although vast majority has not been forested and will not be planted in the future. Drains have been blocked across some of the site. The area has not been grazed from 1970's (although a handful of sheep were seen within the area). There was a fire across most of the area surveyed in 2010. Some areas are hagged.	Suggest that drains have a zone of influence of 30m unless otherwise known (ie. where hydrological survey has been carried out). So amend Q2 to "Drains present within 30m". Add in extra step to Q1, so that if site is categorised as severely eroded then vegetation has to be assessed (Q5). When classed as highly degraded this would indicate that this site is more at risk and that a greater area may end up in severely eroded/bare peat category without intervention after 30 years. To add into descriptions in Q1 whether or not gully bottoms vegetated (and amend description in Q2 to include old hags in drained category). If they are then area is not severely eroded but goes into drained category (since hydrology in these areas still modified). Also need to ensure expert opinion is used when necessary to help ascertain the best restoration methods and their appropriateness.
Eldrick Hill, Dumfries and Galloway (mapping exercise) Surveyed by CCC	Drains (appearing narrow on the aerial image) turn into gullies downstream. This is not a problem as by mapping gullies and drains separately this will estimate the lengths of each needing be restored which will inform estimates of restoration costs. It is clear that all features have to be mapped first before drawing Assessment Unit boundaries. When drawing the Assessment Unit boundaries over areas which are likely to be the same condition category attention should be paid to the likely features which would distinguish them in the field including: change in slop, natural watershed, edge of forestry, fencelines, roads and edge of waterbodies.
Kinmount Buckbarrow, nr Corney, Cumbria	Add in section to SOP describing the things that should be looked at in the field, informed by the mapping prior to site survey.

Section 1: UK Metric for Peatland Restoration

Site & Survey Details	Amendments to Field Protocol Key Findings
Surveyed by CCC and Samantha Hagon from Lake District National Park Authority and Brendan Burley from Cumbrian Wildlife Trust. Site Description: 199ha. The eroded gullies were re-profiled during Oct/Nov 2013. Aerial mapping was carried on year 2004 image, so prior to restoration. Areas where field protocol was tested: restored hagged area, modified (grazed) areas, none peat areas.	Add in tick boxes to section 4 of survey sheet to prompt the taking of photographs at each Condition Assessment location. In section 5 add in sentence to indicate this, linking peat depth to Section 3 (Assessment Unit boundary confirmation). Explain that in hagg and gullied areas only take peat depth measurements on hagg tops. Explicitly state the area to be assessed in the SOP and on tick sheet. Describe actively eroding gullies and those with steep sides of bare peat without vegetation in gully bottom. Need photographs too – given in SOP and guidance. Look at old hagg/draining impact. Change drain to ditch. Extent of bare peat – need to explicitly state that one person walks 20 paces - put this into survey sheet. Need to state explicitly in the SOP that you need to be familiar with what Sphagnum is, able to identify it from other mosses (give links to existing online guidance). Photos would be useful here. Replace “frequent” with regular (implies that there is routine burning as part of management). Just need to reword the question to make clearer. Indicators fine. Again photos would help. Drying and peat loss – Calluna not really applicable here so make this an optional question Explain this on tick sheet and in guidance.
Armboth Fell and Shap and Mosedale Fell (United Utilities), Cumbria, CCC with Samantha Hagon from Lake District National Park Authority and John Gross United Utilities. Armboth Fell – 200ha SSSI owned by United Utilities. The site has been fenced completely	Need to make sure guidance is applicable to a site like this. Further discussion needed. Need to make sure users understand that more peat depth measurements may be required than the standard 12 per Assessment Unit.

Section 1: UK Metric for Peatland Restoration

Site & Survey Details	Amendments to Field Protocol Key Findings
and all stock removed. The area has not been artificially drained or burnt and restoration has just involved stock removal and the planting of scrub on drier slopes (thin peat). Shap and Mosedale Fell – 1700ha owned by United Utilities (largest single area of blanket bog in the Lake District). HLS payments for tenants for complete de-stocking. Some haggs have been re-profiled and artificial drains have been blocked.	As before need to make sure guidance is applicable to a site like this. Further discussion needed and need to make sure users understand that more peat depth measurements may be required than the standard 12 per Assessment Unit. Need to make clear that users should draw upon all data on site eg. peat depth maps and NVC surveys when mapping.
North Pennines Surveyed by CCC and North Pennines AONB Managed grouse moor which has seen extensive drainage with hagg/gully systems in various states of erosion and re-vegetation. Areas where field protocol was tested: drained, hagged (re-vegetated and severely eroding), tarns (completely drained in summer so bare peat)	Need additional guidance for users to assess if gullies are actively eroding (with pictures) that set out the criteria for "actively eroding" gullies (amount of bare peat cliffs and gully bottoms, gully heads particularly important to access). This would make a changing the name of the "Severely Eroded" category to "Actively Eroding" appropriate. Q1: amend to include a third option to describe peat pans and extensive bare peat (but not haggs/gullies) Q2: Change to "Drains (grips) present within 30m" = go to Q3 Q3: Add in option for drained areas which have micro-erosion either side of them which would indicate that these drains could instigate a gullying phase (so "actively eroding").
Racks Moss, Dumfries and Galloway Surveyed by Gearoid Murphy (SNH) Afforested (in parts) raised bog	Questioned why using 40cm and not 50cm (Peatland Action) peat depth criteria Field protocol easy to use and intuitive Suggested that needed a category in there to estimate scrub cover
Ben Lomond, Scottish Highlands Surveyed by CCC	The existing protocol works well for this type of area, correctly identifying the drained units (which were easy to map) and the grazing impact. The site was determined to be mostly drained, with areas in the "Modified" condition category (although indicators for this show that it is only moderately degraded as opposed to highly degraded).

Section 1: UK Metric for Peatland Restoration

Site & Survey Details	Amendments to Field Protocol Key Findings
Upland site which has been drained and is currently grazed	
Carsegowan Moss, Dumfries and Galloway Surveyed by CCC Raised bog drained (and blocked) in parts and small area of remnant forestry.	Clear that the existing protocol does not consider scrub encroachment on raised bog eg. Birch, rhododendron, pine regen. Need to amend Q5 drying and peat loss section to include scrub species along with extensive Calluna as indicator of modification. Other elements of the field protocol translate well to raised bogs
Upland site, South Lanarkshire Surveyed by CCC Blanket bog with areas of extensive historical erosion. These areas are located on the top and shoulders of the hills in this area. Areas are not burned but grazed by sheep (although there are away wintered).	Mapping a site like this would be complex as some gullies healing over, others are still actively eroding. The guidelines for mapping such an area will have to be made clearer (add to a FAQ).
Ysbyty Estate, National Trust, North Wales Surveyed by CCC and Andrew Roberts (National Trust) Upland site which has been drained in the past, drains in some areas now blocked, grazed (although grazing intensity now much lower since Trust acquired site in the 1950's). The National Trust do not burn the site but there was an accidental wildfire over a large area in 2003. Some small areas of actively eroding gullies (but in recovery).	The re-wetted areas of the site, despite being covered by tall (building phase) heather, Sphagnum carpet is just about continuous so this site came out as near-natural. This proves that even when a lot of heather (which indicative of historical drier condition due to the drains) the tick sheet still identifies the site as its current state (ie. very wet, with good bog vegetation despite the remnant tall heather).

Section 1: UK Metric for Peatland Restoration

Site & Survey Details	Amendments to Field Protocol Key Findings
Glaslyn, Montgomeryshire Wildlife Trust, Mid Wales Surveyed by Emily Taylor and Liz Lewis-Reddy (Montgomeryshire Wildlife Trust) Area is grazed with cattle, drain blocking has been carried out, no burning, some areas of active erosions (see second picture below	The protocol established that the areas which were re-wetted have only returned to modified as Sphagnum only in parts. This shows the contrast with Ysbyty and that Sphagnum is the key indicator when considering future Condition categories following re-wetting.
Waskerley, North Pennies Surveyed by Katharine Birdsall, North Pennies AONB Partnership	Need to make clear how do deal with restored re-wetted area in the protocol Further guidance on the time-scale referred to for burning indicator Need to ensure grazing impacts also assessed using management information (in addition to field indicators) Need to ensure that Sphagnum is key species for near-natural – make this clearer. Although need to state in guidelines that a near-natural situation where Molinia is dominant peat forming species can be argued. Ie. key criteria is dominance of peat forming species. Give further guidance on how to deal with a situation where difficult to ascertain degree of modification (ie. ensure understanding that only one Modified Emissions Factor, further sub categories are to help inform future management). Need to ensure Actively Eroding category is clearly stated as being areas with bare peat (relevance of POC)
Rookhope, North Pennies Surveyed by Katharine Birdsall, North Pennies AONB Partnership 330ha site, some areas have been drained, some are bare peat a	Need to explain situation regarding restoration of non-peat (formally peat areas) – do not fit with the data for Emission Factors so not included. Further guidance on the time-scale referred to for burning indicator is necessary Need to better explain the relevance of extensive heather/scrub/purple moor grass indicator of drying and modification. Make sure understand that do not have to meet criteria for all three.

Section 2: Economic Assessment of the Peatland Code: Project Finances, Market Potential and Factors Influencing Enrolment

Andrew Moxey (Pareto Consulting) and Stephen Prior (Forest Carbon Ltd)

2.1 Introduction

This chapter reviews the market for carbon credits, identifying the various factors influencing its development and the potential for peatland restoration alongside other carbon-saving options, notably woodland creation. This includes consideration of factors influencing both the demand for carbon credits and their supply from peatlands given the costs of restoration and likely enrolment of land. Illustrative values and scenarios are presented, but should be viewed alongside the accompanying spreadsheet-based Financial Feasibility Tool created to support project design and planning. Several Appendices contain supporting material underpinning the Financial Tool and values presented.

Restoration of degraded peatlands has the potential to improve a range of ecosystem services. Of these, the Peatland Code (PC) focuses primarily on climate regulation through mitigation of greenhouse gas emissions. This is not to ignore restoration impacts on, for example, biodiversity (see Section 3) and water management, or the potential for non-carbon co-benefits to influence market funding, but does reflect that quantification and valuation of emissions is more advanced than for other impacts.

Although still dwarfed by the compliance market, the voluntary carbon market is growing globally (to over $0.5bn). Peatland restoration does not yet feature prominently in this, but forestry accounts for around 25% of the voluntary carbon market and has some similarities. In particular, like afforestation, peatland restoration incurs upfront capital costs and a time-lag before emission savings accumulate. This means that carbon credits are valued, and often transacted, ex ante before they actually accrue and, consequently, private investors require some assurances about the likely achievement of expected emission savings – leading to the use of risk buffers and monitoring. Projects also need to meet the standard carbon market principles with respect to additionality, double-counting, permanence, and leakage.

In the UK context, the advent of the Woodland Carbon Code (WCC) offers some domestic parallels. In particular, although the design of consistent and transparent internal Code criteria (e.g. for additionality) is important to support investors' confidence, so too is official endorsement of the WCC via, for example, inclusion in Defra's carbon neutral reporting guidance, achievement of PAS2060 status, a presence on Markit, the world's leading voluntary carbon credit registry, and being voted in the top 3 best worldwide voluntary carbon standards in the 2014 Environmental Finance magazine awards. The PC has yet to achieve such endorsements – at core because it has yet to achieve independently accredited status (ie as the WCC has done via UKAS, a route that will require further time and investment) – potentially discouraging some investors and forcing more nuanced marketing language than might otherwise be the case.

The voluntary carbon market can potentially attract a range of buyers, from large corporate entities to individuals. However, potential buyers are more typically small & medium sized businesses (SMEs) with no formal (compliance) carbon reporting obligations but with an interest in improving their environmental credentials. Such businesses are seemingly less risk averse than larger corporate entities with respect to environmental investments and often align investments with marketing activities or staff development.

Experience with the WCC suggests that domestic (i.e. UK-based) projects are of interest, particularly where underpinned by assurance mechanisms, and once made aware of domestic opportunities, businesses may then look for projects close to their (or their customers') location. Buyers may also include those viewing carbon credits as an investment vehicle, to be bought and then sold at a later stage for a profit. In addition to requiring assurances about (e.g.) additionality and risk, such buyers also require some assurances about market liquidity – the ease with which investment holdings can be sold when required. This can be difficult given the duration of and the various uncertainties associated with both forest and peatland projects. The availability of alternatives on the international voluntary carbon market is likely to limit the scope for premium pricing of peatland carbon, and to reinforce the need for robust accreditation.

Gross funding for a given project under the PC depends on buyers' willingness to pay (WTP) for emission savings (and any other ecosystem service co-benefits). However, net funding will typically be less due to the need for risk buffers and operational deductions. Risk buffers are needed to account for the possibility that predicted emission savings do not materialise, and include a "precision" buffer to allow for general scientific uncertainty in estimating emissions and a site-specific "delivery" buffer to allow for potential problems with implementation and durability of restoration actions. Under the WCC, most projects have a risk buffer of 35% to 45%.

Operational deductions are required since applying the PC is not itself a costless exercise. For example, initial and on-going accreditation processes incur some cost, as will conducting project maintenance, and as do the acts of targeting and negotiating with buyers. Equally, market intermediaries and investment buyers may require a profit margin. The magnitude of such deductions is uncertain and may vary across different sites, but deductions are unlikely to be avoided completely since many buyers' confidence in the PC and WTP for peatland carbon will depend on the perceived rigour of assurance and monitoring processes. Possibilities to reduce operational costs, such as the use of remote sensing or shared monitoring data, merit active consideration.

Being able to offer carbon to potential buyers under the PC depends on enrolling land into restoration and on presenting a restoration project in a manner attractive to buyers. The latter rests partly on awareness of the PC and its perceived credibility amongst buyers, but also on the ability of market intermediaries (known as project developers, either private sector or NGOs) to successfully package a site or sites for a target buyer and to then negotiate and support the sales relationship for the duration of the project. These are not trivial tasks and require appropriate resourcing – either as an operational deduction from funding under the PC and/or from other sources. Similarly, perceived market credibility depends on the robustness of the eligibility criteria and the rigour with which they are applied in a consistent and transparent manner, which again requires appropriate resourcing.

Enrolling land into restoration depends on land managers' willingness to accept (WTA) changes to their land use patterns. WTA is likely to be influenced by a range of factors, including understanding of the rationale for and practicalities of restoration but also cultural norms and peer-pressure. Government, NGOs and advisory bodies all have a role to play in promoting understanding and awareness of restoration, but availability of funding is a key determinant of enrolment.

Funding for upfront capital works and at least a proportion of on-going maintenance and opportunity costs is already available, most notably via agri-environment schemes[20] under the Common Agricultural Policy (CAP) and under some water companies' initiatives. However, both the absolute budgets and the payment rates available from existing funding source are perceived to be insufficient to enrol sufficient land to meet ambitious restoration targets. Hence the PC has been designed to attract additional, private funding. It is envisaged that this additional funding will primarily support annual top-up payments to land managers, to compensate for on-going costs (especially opportunity and option costs) not already covered by other funding sources. In some cases, PC funding might be sufficient to cover all on-going costs and/or capital costs, but the presumption is that a mix of funding will be required in most cases.

Given potential variability in buyers' WTP and land managers' WTA - across both different sites but also different buyers and sellers – and uncertainty over risk buffers and operational deductions, a ready-reckoner approach can be used to sketch-out the circumstances under which net funding might be sufficient to cover payments to land managers and/or make contributions to capital payments.

Such an approach reveals that, for likely voluntary carbon market prices with plausible risk buffers and operational deductions, the *Modified* and *Drained* peatland condition categories (as defined in Section 1) are unlikely to generate significant additional net funding – the value of emission savings is too low and in many cases fails to even cover operational deductions. However, the net funding for the Actively Eroding Condition Category is generally sufficient to not only support restoration of that category, but also to cross-subsidise restoration of other categories (the same is true under limited circumstance for the *Drained* category). Comparison of crude estimates of the relative abundance of different condition categories suggests that the area of Actively Eroding land is sufficient to cross-subsidise significant areas of other condition categories.

However, the scope for cross-subsidising will depend on the relative abundance of different condition categories across a given site, or across a project comprising different sites, and on buyers being persuaded to fund (and land managers offer) restoration packages rather than simply concentrating on high-emission-saving Actively Eroding land. This places an onus on the design and marketing of restoration projects to encompass a mix of condition categories, and the pace at which bespoke arrangements for project-by-project deals can be conducted is likely to constrain the rate at which land can be enrolled. At a similarly practical level, scarcity of specialist equipment and skills may also impose a constraint on the rate at which restoration can proceed.

Separately, enrolment will still be contingent on the availability of funding from other sources – the level of net funding under the Code will generally be insufficient to cover all costs – and hence, for example, agri-environment budget constraints will still influence total enrolment.[21] Equally, some projects may fail additionality criteria, possibly on proportionate funding grounds but more probably due to having been initiated prior to the PC being introduced or through there being a strong private business case (e.g. due to water management benefits). Consequently, notwithstanding the arithmetic potential for the Code to provide additional net funding for a large area, actual enrolment in restoration will fall below this.

Although relaxation of additionality criteria to ease access to potential PC funding may seem superficially attractive, adherence to robust additionality criteria will be essential to maintaining confidence amongst many potential buyers– not least since the WCC already has such criteria and is

[20] Although if agri-environment funding is granted on the basis of emission savings, it is not compatible since the same carbon cannot be sold twice.
[21] See also footnote 20

gaining traction in the market place as a result of official endorsement of its rigour. The same applies to choosing risk buffers and the intensity of monitoring activities, although in these cases there may be some scope for revising current criteria if scientific evidence can justify varying them across different condition categories. For example, the effects of grip blocking on drained land may be more certain and require less monitoring than re-vegetation of severely eroded land – so different default risk buffers and monitoring processes might be appropriate.

Estimating likely enrolment through the PC can only be highly speculative, resting on assumptions about a number of key parameters. However, the WCC offers a close analogy. At the Code's launch any woodland planted since 2000 was eligible for registration under the Code, and in 2013 the requirement became that projects could only register within two years of planting. As at 31st March 2015 a total of 199 projects were registered. A large number of those so far registered may not proceed to validation, or may fail to achieve it as projects planted prior to registration will need to provide credible evidence for additionality. To-date, 100 of the 199 projects have been validated, representing 3322 ha and just over 1.58mt CO_2. Over half of this carbon was sold by one project developer, and much of it was sold before the advent of the Code (but validated retrospectively), and so the figure represents sales over a seven year period. Prices achieved under the WCC reportedly fall in the £3/t to £15/t range (compared with £3.40/t to £5.70/t for forest carbon globally), although volume and context are not reported.

If the PC emulates the WCC, both in terms of following the same quality assurance and carbon market based path, and in terms of what the WCC has achieved so far in volume and price, then enrolment will be modest, at least in the early years. In terms of building demand the PC may benefit from having some credible and high profile NGOs involved from the outset, but they will need to accept that much or all of the restoration work they have already completed may not qualify under additionality rules.

2.2 Carbon market overview

2.2.1 Assumptions & background

Underpinning assumptions

- Climate change is now inevitable to some degree or another, and that this is caused in part by emissions of greenhouse gases arising from human behaviour (e.g. from burning fossil fuels).
- Peatlands can help mitigate this through:
    - Storing carbon;
    - Reducing the impacts on society of climate change (e.g. reducing flooding).
- Businesses may wish to voluntarily fund peatland restoration as part of their Corporate Social Responsibility programmes, or as a hedge against possible future compliance carbon targets, and this may include (subject to various restrictions and definitions) making statements about mitigating their greenhouse gas emissions or their environmental impact.

Commonly used terms

- Greenhouse gases, carbon, carbon dioxide and emissions are often used interchangeably. For the purposes of measuring and mitigating the climate change impact of businesses and projects all greenhouse gases are converted to carbon dioxide equivalent, and quantified in 1 tonne units (i.e. 1 tonne of CO_2 emitted, or in the case of an emissions reduction project 1 tonne of CO_2 emissions avoided or captured). The carbon market works on the basis of tonnes CO_2, so for example a business could measure its 'carbon footprint' in tonnes CO_2, then invest in a peatland restoration project that would reduce emission by a similar amount of CO_2.

- The widely used term for an investment in peatland restoration by a business would be 'offsetting' – the achievement of greenhouse gas emissions reductions via funding a project outside of their business and receiving so-called carbon credits in return. Emissions reductions generated by UK based projects cannot be termed 'offsets' because of the potential for 'double-counting' – i.e. the use or potential use of the same emissions reductions by two entities[22]. This situation arises due to the UK government including domestic emissions reductions, no matter how they are funded, in its Kyoto accounting, whilst simultaneously the corporate carbon credit buyer may be 'claiming' the carbon in its own reporting. This may include emissions reductions from peatland restoration - see section 2.2 for further information.
- Because UK based projects are not offsets, they cannot lead to 'carbon neutrality', as it is presently defined, although they can be part of a government[23] and PAS2060[24] supported programme of carbon emissions reduction activity.
- Whilst the inability to use these terms is not an insurmountable barrier it does create problems for large corporates – those subject to various standards, definitions and reporting regimes and with a need to justify their actions to shareholders – and it does create a situation where nuanced language is required where simplicity would be preferable.
- Emissions reductions projects generate what is often referred to as 'carbon credits' – these are units that represent the avoidance or capture of 1 tonne of CO_2 emissions.

Carbon credit issuance and use

- The timing of the delivery of the actual emissions reduction matters, as investors cannot formally 'report' their carbon credits until reductions have happened. Because of the need to attract up-front capital funding to projects that may only deliver reportable carbon credits long into the future a type of 'forward' credit has been developed – called an ex-ante credit. Such credits are normally issued on an estimated amount, less a contingency buffer, for projects that have passed some sort of pre-implementation certification. Ex-ante credits are used to make forward sales of credits more transparent, but cannot be used for formal reporting.
- Ex-post credits are those issued after emissions reductions have been achieved; they are issued in a more exact amount, based on observation of actual performance. Where ex-ante credits have been issued they will be converted to ex-post credits in a numbered sequence as emissions reductions are achieved.
- UK peatland restoration projects will fall into the ex-ante category – although they may begin to deliver some emissions savings immediately there will be a long time lag between when a UK business makes an investment in peatland restoration and when they can realise all of that investment to reduce their emissions via formal reporting. The creation of ex-ante credits (or least the ability to make some quantified ex ante statements) is important in attracting businesses to make a carbon based investment.
- At present peatland restoration is not recognised in the best practice guidance that large businesses would adhere to – Defra's Environmental Reporting Guidance[25]. This presents potential problems for businesses subject to such guidelines, for example the FTSE main list and any other publicly quoted business, but does not prevent other business investing in peatland credits and making statements about their actions (so long as those statements meet UK government green claims guidance).

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[22] https://www.gov.uk/government/publications/environmental-reporting-guidelines-including-mandatory-greenhouse-gas-emissions-reporting-guidance
[23] https://www.gov.uk/government/publications/environmental-reporting-guidelines-including-mandatory-greenhouse-gas-emissions-reporting-guidance
[24] http://shop.bsigroup.com/ProductDetail/?pid=000000000030286698
[25] https://www.gov.uk/government/publications/environmental-reporting-guidelines-including-mandatory-greenhouse-gas-emissions-reporting-guidance

When is a project an emissions reduction project?

There are several principles that projects must satisfy in order to generate credible emissions reductions for the market to invest in.

- **Additionality**: This is the single most important factor and is the ability to demonstrate that the project was only possible due to funding arising from an investment in emissions reductions by an outside party. If a project is 'business as usual' and stands up in its own right (e.g. generates enough other benefits to pay for itself without emissions reductions funding), or was going ahead anyway (perhaps because it was a statutory obligation) then it does not demonstrate additionality and does not qualify. This rule could be a significant stumbling block for projects implemented before the advent of the Peatland Code, unless they can demonstrate that a strong belief in the likelihood of future 'carbon market' funding before the project went ahead was instrumental in the project proceeding[26].
- **Permanence**: The project must lead to the permanent avoidance, reduction or capture of emissions. In reality any project that reduces or avoids is permanent by definition, but capture projects may not be.
- **Conservatism**: Are the projected emissions reductions going to be achieved, and have risks to their non-achievement been factored in?
- **Monitoring**: Projects must be subject to credible monitoring to demonstrate that the predicted emissions reductions are taking place.
- **Baseline**: The baseline scenario is that which would have occurred in the absence of the project, and this should be deducted from the expected emissions reductions to see what the net effect of the project is. The baseline emissions profile may not be constant over time, for example emissions from a given site might be expected to increase in the absence project actions.
- **Leakage**: If the project leads to an increase in emissions elsewhere – for example if a reforestation project caused another area to be deforested to host livestock then this would be leakage. Leakage emissions should be deducted from expected project emissions reductions.

What businesses can and can't say about an investment in UK peatland restoration.

- Businesses would not be able to say: We have gone carbon neutral by offsetting our 2013 emissions through restoring UK peatlands.
- Business could say: In recognition of the fact that our business has an environmental impact we are investing in UK peatland restoration that is expected to deliver, over the next 50 years, carbon emissions reductions that are equivalent to our 2013 carbon footprint. Once restored these peatlands will also deliver a range of other benefits to UK society, including flood management and water purification.

Resolving these issues

Despite all of the above there is a clear demonstration via the Woodland Carbon Code (WCC) that progress can be made in resolving some of these issues. The WCC has created an environment where business can have more confidence in making investments in and statements about the type of payment for ecosystem services project – woodland creation. Using the progress of the WCC as a proxy for the potential for a Peatland Code the beginning and current positions of carbon woodlands should be noted:

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[26] For further information see Valatin, G (2011), *Forests and carbon: a review of additionality:* http://www.forestry.gov.uk/pdf/FCRP013.pdf/$FILE/FCRP013.pdf

- In 2007 all UK-based emissions reductions projects were specifically proscribed in the government's Code of Good Practice for Carbon Offsetting – at the time causing one FTSE 100 company to abandon its early investment in UK carbon woodlands;
- The advent of the WCC has brought woodland creation back to the fore as a potential mitigation activity due to its inclusion in the Defra reporting guidance, its presence on Markit, the world's leading voluntary carbon credit registry[27] and its inclusion in the 2014 version of the PAS2060 guidance. The WCC was also voted in the top 3 best worldwide voluntary carbon standards in the 2014 Environmental Finance magazine awards.

Scope

This section focuses largely on one particular ecosystem service – greenhouse gas emissions reductions (biodiversity is considered in Section 3). This is because:

- GHG emissions reductions are now 'hard-wired' into both UK legislation and the consciousness of businesses and individuals;
- GHG emissions reductions are generally the most visible and easily quantified and monitored ecosystem service, and in fact some ecosystem services will be impossible to quantify and monitor;
- the 'carbon footprint' is a well understood concept and an easy starting point for discussion with potential investors (which is not to say that the conversation will not include other ecosystem services, in fact on the contrary it nearly always will), and the concept of ecosystem services is not well understood[28];
- this section accompanies work aimed at developing default greenhouse gas emissions reduction values for peatland restoration projects, based on using vegetation as a proxy for peat condition. This work is reported in Section 1 of this report and referred to throughout this section as the Metrics workstream.

The market for UK based voluntary carbon projects is presently very small – there is only one company active in developing and selling credits generated under the Woodland Carbon Code, Forest Carbon Ltd, and there has been only one privately funded explicitly carbon driven peatland restoration project. In light of this, this section is necessarily anecdotal in places.

2.2.2 Statutory market and peatlands

Until relatively recently peatland protection had not entered the global statutory carbon market, and it was not until the 2011 Kyoto Protocol conference, held in Durban, that peatlands were explicitly included in the Protocol. How peatlands are to be treated under the Protocol is defined as follows:

> "a system of practices for draining and rewetting on land with organic soil that covers a minimum area of 1 hectare. The activity applies to all lands that have been drained since 1990 and to all lands that have been rewetted since 1990 and that are not accounted for under any other activity as defined in this annex, where drainage is the direct human-induced lowering of the soil water table and rewetting is the direct human-induced partial or total reversal of drainage."[29]

[27] http://mer.markit.com/br-reg/public/index.jsp?entity=project&sort=project_name&dir=ASC&start=0&acronym=WCC&limit=15&name=&standardId=100000000000042
[28] URS (2011): *Barriers and Opportunities to the Use of Payments for Ecosystem Services*
[29] http://unfccc.int/resource/docs/2011/awg16/eng/l03a02.pdf

The EU's own carbon accounting rules were changed in 2013[30] to adopt the decision made at Durban: accounting for Cropland Management (CM) and Grazing Land Management (GM) will become compulsory from 2021 onwards, with accounting for Wetland Drainage and Rewetting (WDR) being optional (in principle, in practice most peatlands will fall under the GM category and so will be accounted for).

Under this definition it appears that all peatland restoration work carried out since 1990 could be included in the UK national inventory, potentially creating the same double-counting issue that forestry faces because both the government and the corporate carbon buyer could be seen to be claiming the same project. As the double-counting situation is created by the UK's participation in the Kyoto Protocol it is worth briefly considering its current and future status.

It wasn't until the very end of the first Kyoto commitment period, in December 2012, that the shape of the following period was known, and with major GHG emitting nations either having never participated (e.g. the US, China), or having withdrawn (e.g. Japan, Canada, Russia, New Zealand), the countries covered by the protocol now account for just 15% of global emissions and the reductions targets they aim to achieve are insufficient to prevent global temperature increases. The UK and the EU remain strongly supportive of the Protocol process, and its emissions reduction targets.

At the 2011 Kyoto conference in Durban the Durban Platform for Enhanced Action was agreed – to all intents and purposes this was an agreement to start again and produce a new protocol by 2015, to take effect in 2020. There is a great deal to be resolved - mitigation, adaptation, finance, technology transfer, capacity building, compliance mechanisms and institutional arrangements - and at this stage there are more questions than answers. Interestingly, the new mechanism would not come into force until 2020 - the year by which developed countries are recommended to have already reduced emissions by 25-40%.[31]

2.2.3 Voluntary carbon market

In examining the voluntary market a review of the forest carbon market has also been conducted as this is the largest and most well developed LULUCF (Land Use, Land Use Change & Forestry) element of the voluntary market, is the only such market in existence in the UK, and can be seen as an indicator for potential peatland carbon market. More information can be found in Appendix 2.2.

The voluntary market accounted for less than 0.1% of the global carbon market in 2011 (with the balance being the compliance market) but the price paid by buyers has shown itself to be resilient in the face of the significant decreases in compliance market prices brought about by technical, legislative and credibility issues. Reported volumes and prices in the voluntary market 2011 and 2012 are shown in Table 2.1.

[30] EU (20130; *Decision No. 529/2013/EU of 21 May 2013 on accounting rules on greenhouse gas emissions and removals resulting from activities relating to land use, land-use change and forestry and on information concerning actions relating to those activities,* Official Journal (EU) L 165/80 of 18 June 2013

[31] Climate Focus (2012): *CP17/CMP7 Durban Debrief*, Climate Focus

Table 2.1 Voluntary market volumes and prices 2011 and 2012[32]

Standard / market	Volume ($MtCO_2eq$)		Average price (US$/$tCO_2eq$)		Value (US$M)	
	2011	2012	2011	2012	2011	2012
Over the counter	93.0	98.5	6.2	5.9	572.0	515.7
Exchange traded	2.0	2.3	2.10	2.74	4.2	6.3
Historical tracked	1.8	-	6.05	-	10.9	-
Total	**97.0**	**101.0**	**6.05**	**5.18**	**586.5**	**523.0**

NB Exchanged traded prices were not included in the original report and have been inferred here from the other figures. This has also changed the weighted average prices.

The forest carbon market in turn accounted for around 24% of the total voluntary market and has grown steadily in value – from $45m traded in total in the period before 2005, to $237m traded in 2011 and $216m in 2012[33].

Major buyer sectors included manufacture, transport, retail and financial services. Major buyer motivations included Corporate Social Responsibility (CSR) programmes, early action against a possible future compliance regime, and branding. So far only European buyers have expressed an interest in European projects, and there is increasing interest in Europe for home-based projects despite the 'non-offsets' problems that will arise from them (as is the case with UK projects – Section 1.1).

Europe is the region with the largest demand – accounting for just over 20% of market value and 50% market volume. The bulk of purchases within Europe were from renewable energy projects in Asia – typically traded at a low price reflecting a portfolio approach (i.e. a significant proportion from low-cost projects mixed with some high cost 'charismatic' carbon credits).

Average prices in the forest carbon market in 2010 were $5.50/$tCO_2$; in 2011 they were $9.20/$tCO_2$, and in 2012 they were $7.80/$tCO_2$.

Most activity in the forest market is certified either to VCS (Verified Carbon Standard – the world's leading voluntary carbon standard) or via the Clean Development Mechanism – one of the Kyoto Protocol's flexible mechanisms. The world's other major voluntary carbon standard – the Gold Standard – has now bought the forest-based CarbonFix standard to move into the forest carbon market. None of these standards are applicable in the UK as all would require credits to be full offsets.

2.2.4 Voluntary market and peatlands

There have been some examples of voluntary peat carbon projects and transactions around the world:

- The MoorFutures project in Germany has developed its own certification standard, meeting all accepted carbon project principles. The standard lacks formal accreditation and independent audit, but is underwritten by regional government and has carbon data and monitoring carried out by local universities. To date the standard has sold 9,500 credits in the German voluntary carbon market (mostly to individuals, not corporate buyers), at an average price of €37.50, and the MoorFutures web site currently advertises two projects, covering 65 ha and 10 ha, and

[32] Ecosystem Marketplace (2013): *Manoeuvring the Mosaic: State of the Voluntary Carbon Markets 2013*
[33] Ecosystem Marketplace (2013): *Manoeuvring the Mosaic: State of the Voluntary Carbon Markets 2013*

priced at €35.00/t and €67.00 respectively[34]. MoorFutures could not be said to be a direct comparator to the Peatland Code as it is presently structured.

- The RSPB, along with other partners, has rewetted 17,000 ha of peatland in Belarus – expected to prevent emissions of around 30,000 t CO_2 per annum[35]. A framework was created for the potential trading of CO_2emissions reductions from this work but to date the necessary methodology is still undergoing review by independent assessors under the Verified Carbon Standard and hence no transactions are possible[36]. As at March 2015 this methodology was undergoing its second assessment under VCS[37].
- In 2013 the Australian government announced the premature termination of its planned peatland rewetting partnership with Indonesia. The project had aimed to reduce CO2 emissions by restoring 200,000 ha of drained peatland on the island of Kalimantan but was initially scaled back to 25,000 ha and then finally cancelled[38].
- Peatlands Plus Ltd developed a project at the Alladale Estate, in Sutherland, in 2010 that rewetted over 200 ha of peatland on behalf of ICAP's CSR programme.
- The development of an ecosystem services investment prospectus[39] by Montgomery Wildlife Trust for its Pumlumon project has met with some limited success[40].

2.2.5 UK domestic voluntary carbon standard: Woodland Carbon Code

Background

The Woodland Carbon Code (WCC) was launched by the Forestry Commission in July 2011 after four years of consultation and development and a year's pilot phase, and has no direct international comparator in being a credible domestic voluntary LULUCF carbon certification mechanism (although in 2014 and 2015 the Forestry Commission and Forest Carbon Ltd have met variously delegations from South Korea, Japan, Austria, the Netherlands, Germany, Turkey and Switzerland, all seeking information about the WCC). The Code's development represented a significant breakthrough in domestic carbon policy – arising as a consequence of lobbying by the UK carbon and forestry industries after the publication of the government's 2007 Quality Assurance Scheme for Carbon Offsetting, which had explicitly proscribed UK-based projects. The Code's purpose is to give confidence to the buyers of carbon credits arising from new UK woodlands that these credits are genuine, additional and credible.

The WCC provides a clear set of standards for landowners and woodland managers and ensures that new woodlands certified under WCC are responsibly and sustainably managed. The transparent and consistent approach to documenting woodland creation projects means consumers and investors are confident that their projects are delivering verifiable benefits. To meet the requirements of WCC projects must:

- be managed sustainably and responsibly to the UK Forestry Standard;
- have a long-term management plan;
- use standard methods for estimating carbon dioxide sequestration by growing trees, and monitor the carbon stock at intervals throughout the project duration;
- allocate a proportion of the carbon sequestered to a "shared buffer" which can be called upon in the event of the project suffering any losses;

[34] http://www.moorfutures.de/en/projects/latest-offers, as at 17th October 2014
[35] http://www.rspb.org.uk/ourwork/science/research/details.aspx?id=362865#objectives
[36] http://www.v-c-s.org/rewetting_drained_peatlands_GEST
[37] http://www.v-c-s.org/methodologies/baseline-and-monitoring-methodology-rewetting-drained-peatlands-used-peat-extraction.
[38] http://www.smh.com.au/federal-politics/political-news/australianindonesian-carbon-project-abandoned-20130702-2p98w.html
[39] http://www.montwt.co.uk/images/user/Pum_brochure.pdf
[40] Personal communications with the Trust

- demonstrate that the project delivers greater benefits than would otherwise have been achieved (see Additionality rules in Appendix 2.4);
- maintain certification to the code.

In 2012 UK woodland creation, in the shape of ex-post WCC credits, was added to Defra's Greenhouse Gas Reporting Guidance as a legitimate means of mitigating net emissions[41], and from October 2013 it was mandatory for FTSE main list companies to report their emissions using this guidance (although they are not compelled to take any action). Whilst this represents considerable potential demand, woodlands also experience the same issues with temporal misalignment as those for peatlands outlined in section 1.1.

Progress of the Woodland Carbon Code as at 31st March 2015

At the Code's launch any woodland planted since 2000 was eligible for registration under the Code, and in 2013 the requirement became that projects could only register within two years of planting. As at 31st March 2015 a total of 199 projects were registered (including 100 validated projects). A large number of those so far registered may not proceed to validation, or may fail to achieve it as projects long planted prior to registration will need to provide credible evidence for additionality. Table 2.2 below shows validations to date.

Table 2.2 Woodland Carbon Code validations as at 31st March 2015[42] Source: Forestry Commission

Location and type	Number	Hectares	$ktCO_2$
England	43	895	498
Scotland	53	2,367	1,055
Wales	3	52	33
Northern Ireland	1	9	3
Total	**100**	**3,322**	**1,588**

After three years of the Code's existence just over 3,300 hectares of new woodlands have been validated, with around 55% of the carbon credits arising from these projects (just over 1.58$mtCO_2$)[43] having been sold. It is worth noting that a significant majority of this carbon was sold by one project developer, and much of it was sold before the advent of the Code (projects have been validated retrospectively), and so the figure represents sales over a longer period (7 years).

Price information

Because the Woodland Carbon Code operates on an over-the-counter (OTC) basis very little price information is publicly available. The Forestry Commission reports prices in the range £3/tCO_2 to £15/tCO_2, but much of the information underpinning those figures dates from a time before the Code, and so registry, initial and ongoing certification costs were not known or incorporated. Ongoing certification costs are still not known as the accepted monitoring techniques and methodology are still under development. A workshop to complete this phase of the Code development was conducted in April 2014 – involving stakeholders, academics and technology developers involved in remote sensing – and a trial certification programme is commencing in summer 2015. Even when this is in place caution should be exercised when reviewing carbon credit prices as there will be a degree of variability as to

[41] Defra (2013): *Environmental Reporting Guidelines: Including mandatory greenhouse gas emissions reporting guidance*
[42] http://www.forestry.gov.uk/pdf/wccmar2015.pdf/$FILE/wccmar2015.pdf
[43] Analysis from holdings data on the Markit Registry

what is included in or excluded from the price: e.g. ongoing monitoring and certification, carbon credit 'insurance' (some sort of guarantee of the delivery of carbon in the unlikely event of project failure), and ongoing marketing support.

There also is also only one known validated project that have been developed without Forestry Commission grant aid; validated projects represent those at the margin (i.e. many projects proceed to planting without carbon funding because grant aid is sufficient, some will not proceed to planting even with grant aid and carbon funding because carbon credit prices are not high enough, and in between will be projects where the combination of grant aid and carbon funding is sufficient). Nonetheless prices will be a useful reflection of the willingness to pay by what are voluntary market participants.

Markit Registry

The WCC reached the final stage of its development as a credible means of mobilising carbon funding with its entry to the Markit Environmental Registry in July 2013. The Markit Registry is the world's leading host of carbon and environmental project and credit data and offers the following benefits:

- public availability of background documents for all Woodland Carbon Code validated projects;
- the issuance of carbon credits, all with unique serial numbers, arising from validated projects;
- the ability to own and transfer woodland carbon credits to corporate buyers and investors;
- the ability to cancel credits (called 'retirement') when they have been used by a company as part of their carbon footprint - creating confidence for their customers that claims made are true.

Because of its transparency and traceability the registry offers the credibility needed to make smaller purchases – allowing buyers to know which woodlands their credits arise from and that they haven't been 'double sold'. Previously most transactions would have been by corporates, in the volumes necessary to buy a whole project's carbon. The registry could underpin the ability to offer better access to the market for individuals and small businesses looking to make a credible and quantified contribution to the mitigation of climate change.

2.2.6 Conclusions

- Prices in the voluntary market and specifically in the forest carbon market looked to have risen in 2011 and then fallen in 2012, but the market has too many variables (e.g. project type, location, certification, buyer motivation) for one 'true' price to be established. In the face of what could be described as a loss of credibility in elements of the global carbon market since 2011 voluntary carbon, and in particular 'charismatic' projects such as forestry, has held its value.
- There are indications, from the data and anecdotally, that the Woodland Carbon Code has arrived at the right time to capitalise on increasing interest in within Europe and the UK – the world's largest voluntary carbon markets – for local projects.
- Forest carbon projects are an important part of the project portfolio for many voluntary buyers.

2.3 Research and Scenarios

2.3.1 Demand

The following information is a synthesis of existing market research work:

- by others for the Peatland Code[44],
- by Forest Carbon for internal purposes and for use in consultancy work[45], and
- by other organisations for general use.

As with previous sections the UK forest carbon market is also considered as it is an indicator of potential interest in peatland carbon, and as there is only one peat carbon transaction to date in the UK.

2.3.1.1 Buyer attitudes, interest and level of understanding

Attitudes to climate change, carbon reporting and carbon offsetting

- Whilst many businesses are aware of and 'believe in' human induced climate change, and understand the broad concept of offsetting, very few are aware of the finer technicalities of offsetting, as outlined in Section 1.1.
- For those engaged in some sort of compliance programme (EU-ETS, Defra Mandatory Carbon Reporting, mainly therefore the larger businesses) the primary driver is in-house emissions reductions before offsetting is considered (this is both as it should be in terms of offsetting best practice, but also has the potential to at least partly pay for itself through savings).
- Where reporting level businesses are offsetting, on the whole they (a) are price sensitive, (b) want offsets to deliver more than just carbon emissions reductions, and (c) to date have valued the 'carbon neutral' label afforded by full offset status credits. For most of these buyers, certainly as far as core operational emissions go, UK 'charismatic' carbon (such as Woodland Carbon Code or peatland restoration) would historically have been seen as a cost added to a cost. Anecdotally it can be reported that there has been an unfreezing of this attitude recently, with some businesses considering 'repatriating' at least a portion of their offset spend and investing in UK woodlands.
- Between 2012 and 2013 there was a slight increase in the number of FTSE 100 companies engaged in offsetting – from 13 to 19. In 2013 six FTSE 100 companies claimed carbon neutrality but only one had met the PAS2060 carbon neutrality standard[46].
- Despite progress over the years in corporate carbon reporting overall, Scope 3 emissions – indirect emissions incurred in supply chains or bought in goods and services – remains a significant unexplored and unreported area[47], and one where there could be an opportunity for UK-based projects implemented by businesses in the supply chain of larger entities.
- There is a significant difference in the sophistication of the response to climate change risk between FTSE 100 and FTSE 250 companies[48]. This in turn suggests a poor level of knowledge and response in businesses below this size, and this is borne out by direct experience and research – SMEs on the whole do not have the necessary resources to manage a sustained in-house carbon emissions reduction program unless they are involved in some mandatory regime such as the CRC.
- Reporting level businesses that are not concerned about the offset/non-offset, and ex-ante/ex-post issues are in a small minority.
- For many businesses the initial drivers for environmental actions are legislative, and cover a range of activities (climate change, waste).

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[44] Inman, A. (2013): Peatland Carbon Code PES Pilot: Market Research Report
45 Prior, S.D., Hepburne Scott, J.P., and Watt, G. (2013): Carbon market opportunities for Scottish forestry, Forest Carbon report for Scottish Enterprise
[46] Carbon Clear (2013): Carbon reporting performance of the FTSE 100, Carbon Clear
[47] CDP (2013): Are UK companies prepared for the international impacts of climate change?
[48] CDP (2013): *Are UK companies prepared for the international impacts of climate change?*

Knowledge of and attitudes to the UK payment for ecosystem services market

- For those businesses where Defra guidance is relevant, the time gap between funding a project and receiving reportable ex-post credits is something they are aware of. Nonetheless the reportable element of a CSR investment is attractive, even if delayed.
- The addition of the WCC to the Defra Environmental Reporting Guidance is seen as a 'vote of confidence' in the WCC by all levels of business, although the guidance and reporting programme are not relevant to most of them.
- Whilst the WCC took some time to gain traction there has recently been an increase in the number of enquiries based on its existence. Nonetheless a significant majority of businesses are still unaware of the Code and Markit developments.
- Conversations with the U.K.'s largest offset retailers about woodland creation in the UK have only become possible since the advent of the WCC– and in fact in several cases it has been the Code's acceptance onto the Markit Registry that has provided the real stimulus. At the time of writing a handful of WCC transactions have been completed via large offset retailers.
- Most offset retailers are members of the International Carbon Reduction and Offset Alliance (ICROA). ICROA's initial response to the launch of the WCC was guarded, but there have been constructive conversations between ICROA and the Forestry Commission in the past months.
- There is generally a very positive response to the Code, and the Markit Registry, once it is fully understood. It is seen as overcoming reservations and making UK woodland creation a viable part of a carbon "offset" strategy (whilst understanding that the credits were not offsets).
- The social benefits of UK woodlands are seen as a vital part of the decision to invest.
- It is most likely that, for the time being at least, investment in UK payment for ecosystem services projects would only ever be part of a wider portfolio for companies subject to reporting guidance.
- When prompted to name UK ecosystems services projects (once the concept is explained) most business would identify woodland creation ahead of peatland restoration.
- For businesses outside of any carbon reporting regime that are undertaking offsetting with credits from outside the UK the UK Woodland Carbon Code is attractive – offering a relatively local 'more than just carbon' option. Companies in this category are, on the whole, comfortable with the 'non-offset' status of such projects and are happy to highlight the contribution they are making to the UK environment, but require support in using the correct terminology.

2.3.1.2 Opportunities for peat carbon

Categories of buyer

Broadly speaking there are 6 categories of potential buyer for peatland ecosystem services projects:

- Large corporates, subject to EUETS
    - These are perhaps the least likely buyers, subject as they are to a compliance carbon reporting and management regime aimed at reducing their consumption of resources.
    - Forest Carbon Ltd has had several conversations with such companies over time about woodland carbon investment and to date none has proceeded to a transaction.

- Large corporates, subject to MCR
    - As already outlined these businesses are now adjusting to a new carbon reporting framework and this may, over time, encourage offset buying activity where none was previously taking place.

- Ex-post crediting is likely to mean that this audience – and businesses that expect to be included in the regime in the future (e.g. at present MCR covers FTSE Main market companies, but could in time be extended to, for example, FTSE AIM companies) – may remain largely out of reach for some time to come.
- One finding is that companies of this stature tend to be very risk averse when it comes to environmental claims – some have experienced negative responses to their actions from environmental NGOs. This may, in the short term at least, reduce the likelihood of these businesses being large buyers of WCC credits or peat carbon credits.
- There are nonetheless examples of companies from this category that are buying WCC credits.
- There may be an opportunity for peatland restoration to be a reportable activity under London Benchmarking Group (LBG) guidance. A meeting between Forest Carbon, Grown In Britain[49] and LBG in February 2014 highlighted two specific areas of the LBG Guidance Manual Volume 1: Inputs[50] that could be applied to UK woodland creation (and equally to peatland restoration), and a section of the LBG Outputs and Impacts Working Group report[51] that would also be applicable to woodland creation (and peatland restoration). Because LBG Guidance is focused on inputs and community activities the 'non-offset' status of such projects is not relevant and it could provide a means to enable peatland restoration projects to dovetail with corporate community investment.

- <u>Businesses subject to CRC</u>
  - For many businesses subject to the CRC there has been an administrative burden, as well as the actual cost in terms of failing to meet CRC targets and paying 'fines'.
  - Several businesses have expressed surprise that WCC credits could not be used as part of the CRC, and a wish to see this change in order that they could see at least some of their carbon 'tax' at work in new woodlands they could identify themselves with.

- <u>SMEs with no formal carbon obligations</u>
  - Experience and research suggests that this is the likeliest area to achieve success.
  - Businesses at this level are much less risk averse with respect to environmental messaging, and are more able to respond to the opportunities presented in terms of incorporating the activity in marketing or staff development. It may also be easier to match such businesses to projects local to them.
  - For UK SMEs the buying of imported full offsets may have limited value, and credits such as those generated by the WCC or peatland restoration, particularly where projects are local, are a very real alternative. Interestingly Forest Carbon's experience to date has been that businesses will first become interested in involvement in UK based projects, and then begin to seek out projects closer to home (rather than seeking involvement because a project near them). This has been borne out by experiences in selling WCC credits from a flood mitigation program in the Tweed Valley – sales to date have been to London and South-West based businesses despite thorough communication of the opportunity with Tweed Valley businesses.

- <u>Individuals</u>
  - This is a largely untapped market at present. Offset retailers report that attempts in this direction, a number of years ago, were unsuccessful due to the burden on individuals in

[49] http://www.growninbritain.org/
[50] http://www.lbg-online.net/media/5595/lbg_guidance_manual_vol_1_inputs.pdf
[51] http://www.lbg-online.net/media/13256/making_a_difference_management_report.pdf

supplying footprint data, and the remote location of offset projects available at the time.
    - At present the Markit registry rules would prohibit individuals from opening accounts and owning UK woodland credits.
    - Reaching individuals as buyers would require: re-sellers (e.g. via tourism operators, event managers, NGOs), a simple and transparent central means of publicly recording an individual's purchase, a range of project locations to choose from, and a strong and simple message being communicated by organisations with a wide ranging public credibility (e.g. via high profile events).

- Investors
    - This market is touched on in Section 2.3.

Conclusions

- Buyers are not homogeneous and differential marketing strategies will be needed to target different market segments.
- Businesses already subject to any form of carbon levy are less likely to participate.
- The most likely corporate participants are SMEs, businesses that are not carbon emissions intensive (e.g. service based), businesses where the carbon credits can be hypothecated to sales activity.
- The sale of credits to individuals has not yet been fully explored, and tourism represents a good opportunity to do this as it is an industry that relies on unavoidable emissions (e.g. people need to travel to be tourists).

2.3.2 Liquidity

2.3.2.1 The need for liquidity

In any market there is an important role to be played by providers of liquidity that even-out peaks and troughs in supply and demand. In a payment for ecosystem services market this may be integral to success as upfront funding is required to deliver projects where supply will either be surplus to immediate demand or not materialise for a long time (because it takes time to deliver ex-post credits).

In the UK forest carbon market the advent of the WCC, and Markit Registry, have gone a long way towards 'de-risking' the proposition in the eyes of some private investors, but nonetheless even here there may still be areas of market failure that could require some form of public investment, at least initially. In the peat carbon market that may be further accentuated in the short term as it lacks the infrastructure of the rest of the carbon market.

2.3.2.2 Liquidity issues specific to the UK payment for ecosystem services market

There are several areas where market failure may prevent significant expansion of the UK PES market.

Complexity

This is a new market with varying degrees of development. It has its own nomenclature, a set of acronyms, rules originating from many sources, and controls on the sort of language that can be used to describe it. Research and experience in this market reveals that even investors otherwise knowledgeable about finance (or forestry, with respect to the Woodland Carbon Code) may not grasp things sufficiently well.

Complexity is also a reason why the UK forest carbon market has been closed off, for the time being at least, to individual investors. The sort of asymmetric information that occurs in the carbon market – due to its novelty, its unusual nature, its impenetrability to the uninitiated, and a lack of price transparency – has led to mis-selling of carbon credits to the public by unscrupulous businesses in the past few years[52].

Uncertainty

There is only a small body of sales evidence to support research by potential investors in UK PES projects looking for exit price information. To date there are 89 validated WCC projects, which have generated around 1.5m PIUs (the ex-ante credits issued by the Woodland Carbon Code). Of these 78% have been sold in over the counter transactions (and therefore without price visibility), while the rest remain unsold[53].

It should also be remembered that at present the main exit route would be via sales to voluntary buyers. There are government policy influenced exits in existence, and others that are at varying stages of lobbying or discussion, but at present even those routes remain voluntary (and of course subject to change).

Short term misalignment

Implementing PES projects (such as woodland creation or peatland restoration) can be a long, expensive and difficult process, and landowners, possibly tenants, and investors need certainty at the outset that all revenues, including carbon credit sales income, can be achieved. At present the market operates largely on exactly matching sellers with buyers – with only one company providing any degree of liquidity to projects. On the whole, at present, if no buyer can be found then good projects may not proceed as the landowner or project developer looks for alternative land uses or investments.

This short term misalignment problem can also prevent the market being accessed by small carbon credit buyers. For this to succeed someone would need to be willing to invest in the credits from a given project and sell them in tranches to small buyers, possibly with the risk that not all would be sold, and on the understanding that once even a small amount had been sold the project may cease to be attractive to a larger buyer.

Long term opportunity

Although it is possible to exit an investment in UK PES in the short term, via the sale of ex-ante credits, it may be that there is significantly more value to be achieved through the sale of ex-post credits in the future. At present there are two problems:

- The time scale in this scenario may be longer than many private investors are attracted to (up to 100 years to achieve all the returns, assuming a carbon market still exists that far into the future).
- There is no evidence yet of what the future price of ex-post credits might be. The current price of 'premium' carbon credits is known, but as they have full offset status there is no direct comparison.

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[52] http://www.fca.org.uk/consumers/scams/investment-scams/carbon-credit-trading
[53] Analysis from holdings data on the Markit Registry as at 29th July 2014

2.3.3 Supply

2.3.3.1 Landowners and land availability

Context

Conversion of land to a long term PES project is a decision which requires very careful consideration – in the case of woodlands it is irrevocable in law, and even without this requires a commitment measured in many decades. The factors in favour are generally marginal for the existing owner and the factors against are many – practical, financial (i.e. the opportunity cost of alternative land use), perceived or real burden on title, and cultural. Many farmers are the descendants of generations on the same holding for whom converting substantial land area to non-agricultural use would go against peer pressure and family tradition.

In addition many areas favourable for peatland restoration will either be tenanted, or be subject to common grazing rights, and this can add a significant layer of cost and complexity to a project (assigning PES rights, gaining enough support from commons rights holders to proceed).

Land availability

The latest Committee on Climate Change upland peat indicators report[54] shows that:

- there are 355,000 ha of upland deep peat in England;
- of this 16,000 ha are in good condition;
- 111,000 ha are currently being restored;
- 143,500 ha could be said to be readily available for restoration (comprising gripped, gully and burnt land), with a further 25,000 ha under forestry, 3,000 ha bare peat and 56,500 ha unknown condition.

2.3.3.2 Barriers to the implementation of Peatland Code restoration projects

There are likely to be financial barriers to implementation of projects that could attract private sector PES market investment in peatland restoration:

- There will be the project level disincentive of a long term loss of farm or estate income (the minimum contract duration under the Peatland Code is 30 years but experience of the market suggests that 50 years is the shortest period seen as credible by investors) in return for short-term PES grants and either a one-off PES market payment or a potential future stream of uncertain PES income.
- There will also be the challenge of demonstrating additionality: on an individual project level where there are sufficient grants in place to fund restoration; and on a nationwide level for projects where work has already been completed using public funds.

Another financial barrier will be that already touched on – the temporal misalignment between the high upfront costs of PES projects and the point at which they deliver 'reportable' benefits.

PES projects are also typically complicated to set up and require long-term monitoring and re-certification. If this process is not designed and managed cost effectively than there is a risk that compliance and transaction costs can outweigh the actual cost of project implementation – creating a disincentive to both landowner and investor. This issue is currently being resolved for the Woodland

[54] http://www.theccc.org.uk/charts-data/adaptation-indicators/upland-peat-indicators/uptake-of-peatland-restoration/

Carbon Code – almost a full three years after the Code was launched – but it is expected that the methodology and protocol will be proportionate to the standard and its typical projects.

Peatlands have been subject to a wide variety of policy interventions – e.g. Water Framework Directive, Habitats Directive, SSSI status, agri-environment payments – and it may be difficult to unravel these for a specific project to assess additionality and double counting.

It is also to be expected that in time there could be legal issues surrounding PES projects – at least until the market is more mature. Risks may include: inadequately specified contracts, the potential complexity of selling different ecosystem services to different buyers from the same piece of land, and title disputes unless projects are entered on deeds or searches of the relevant registry (e.g. WCC registry) become a standard part of the land sales process.

2.3.4 How much peatland restoration can the Peatland Code deliver?

2.3.4.1 Introduction

Targets for peatland restoration are ambitious and will require significant resources if they are to be achieved. In recognition of the constraints on public-sector budgets, the Peatland Code has been designed as a means of attracting additional private-sector support for restoration. To encourage more land managers to enrol in restoration programmes, it is anticipated that private funding will be used to offer additional annual incentive payments and/or to contribute to upfront expenditure (Appendix 2.4 offers some discussion on estimating enrolment rates).

The gross additional funding secured via the Code will depend on the valuation placed by private investors on restoring a given site (or, in a bigger project, sites). Since not all sites nor all investors are alike, valuations are likely to vary somewhat. For example, some sites may appeal more to specific investors due to their location within an iconic landscape or proximity to designated conservation areas. Equally, some investors may be particularly attracted to sites with possible biodiversity (e.g. charismatic or keystone species) or water management (e.g. visual quality or peak flows) benefits from restoration. Such influences are difficult to generalise or to map using available data since they depend on investor-specific traits and/or site-specific attributes.

Partly for this reason, funding under the Code is assumed in the first instance to be determined purely by carbon revenues. These are easier to generalise since they depend on carbon prices (which are reported sufficiently to allow the projection of a likely range of prices) and the expected emission savings under restoration (which are specified in the Code's field protocols developed through the Metrics research). All other things being equal, higher emission savings and/or higher carbon prices will generate higher funding levels.

Even where funding is available from a combination of public and private sources outlined above, as with other land-based mitigation options, achieving the technical potential of peatland restoration to reduce net GHG emissions depends on the willingness of land managers to enrol in a restoration programme. That is, estimation of Marginal Abatement Cost Curves (MACCs) involves some judgement of uptake as well as of the technical potential of mitigation options.[55]

Willingness to enrol in a peatland restoration programme may be influenced by a number of factors, including awareness, cultural norms and peer pressure but financial incentives are important. Crudely,

[55] For example, see Moran et al. (2008) UK Marginal Abatement Cost Curves for the Agriculture and Land Use, Land-Use Change and Forestry Sectors. Report to the Committee on Climate Change, London.
http://www.knowledgescotland.org/images_db/ukmarginalabatementcostcurves.pdf

land enrolment (i.e. hectares under restoration) is likely to increase with rising net (of costs) payments to land managers: at low payment rates, only low-cost[56] sites are likely to be enrolled; as payment rates rise progressively more expensive sites will be enrolled.

Variation in restoration costs across different sites reflects local biophysical conditions that affect ease of restoration. For example: the extent of bare peat and gullies, the presence of drainage, the removal of scrub and the remoteness of a site. However restoration costs also include the opportunity costs incurred by displacing current land uses. Some activities may be compatible with restoration and could continue, albeit perhaps at a lower intensity – for example extensive grazing and grouse shooting. Other activities will be displaced completely by restoration – for example, forestry and intensive arable cropping (but might be replaced by another activity).

Although low-cost sites may be characterised as being currently under low-profitability land use and relatively easy to restore whilst high-cost sites may be characterised as being currently under more profitable land use and/or being harder to restore, the actual spatial distribution of costs across sites is unknown. This applies especially to opportunity costs which can depend on business size and structure plus managerial competence as much as on biophysical conditions. Opportunity costs are thus difficult to observe: *only the wearer truly knows where the shoe pinches*.

In addition landowner attitudes to the potential for profit that could arise from the sale of ecosystem services following restoration will differ widely. Whilst some landowners will be satisfied with a recovery of cost (including opportunity cost), others will be interested in a profit beyond this (on the basis that if ecosystem services rights can be sold to buyers for more than their total cost, then the landowners would want to share in that surplus). Some instances of this attitude will arise due to expectations of higher future values of ecosystem services rights, and it may cause landowners to delay participation (anecdotally this has happened on occasion under the Woodland Carbon Code).

Consequently, estimation of enrolment and generation of a subsequent mitigation supply curve for peatland restoration is essentially a speculative exercise - although not necessarily any more speculative than for other mitigation options included in published MACCs.[57]

2.3.4.2 Net funding

Not all of the gross additional funding (i.e. carbon revenue) secured under the Code will necessarily be available to land managers since the Code can itself require some operational deductions. Specifically, there are initial and recurrent accreditation and administrative costs associated with securing and maintaining private funding, including the process of finding and then matching buyers and sellers of peatland carbon plus, given the long term nature of the buyer/seller relationship, the provision of on-going support to both parties. In addition, to account for delivery risks arising from restoration failure or reversal (e.g. wildfire), a risk buffer has to be applied to gross carbon available (although some of this buffer may be released over time if risks do not materialise). Separately, some private investors or their intermediaries will require a financial profit margin. Where any such deductions are incurred, the funding available to land managers for restoration will be reduced.

Estimates of operational deductions under the Code are subject to a degree of uncertainty. For example, the nature and regularity of accreditation has yet to be finalised and some investors or their intermediaries (e.g. NGOs) may be willing to absorb organisational transaction costs and to forgo any profit. Equally, observed voluntary carbon market prices currently vary and may be higher or lower in

[56] Where costs include all costs e.g. capital works, opportunity costs, on-going management etc..
[57] Again, see Moran et al. op. cit.

the future whilst sites differ widely in terms of baseline conditions, required restoration activities, emission savings. Delivery risk will vary with site conditions and managerial competence but also scientific uncertainty.

Nevertheless it is possible to explore the interaction of potential emission savings (as generated by implementing projects that create a 'shift' from one of the peatland Condition Categories[58] identified in Section 1 to another – improved – Condition Category)[59], carbon prices and deductions under the Code to reveal the circumstances under which net additional funding could be achieved. Table 2.3 presents some illustrative results, reported as possible annual incentive payments (£/ha/yr) to land managers assuming that no contribution to capital costs is required and either a 35% or 45% risk buffer has been applied.[60] Operational deductions would not necessarily be incurred each and every year (e.g. upfront accreditation), but for simplicity are presented as an equivalent annual charge.[61]

Table 2.3 uses the same information as the Financial Feasibility Tool, but presents figures on a per hectare basis and allows comparisons of different carbon prices, operational deductions and risk buffers (the tool can do this but would need to be run repeatedly for different scenarios). Moreover, whereas the financial tool considers all costs and revenues, Table 2.3 considers only costs incurred under the Code and revenue derived from the Code-related funding. Hence the spreadsheet-based financial tool offers more detail and is better suited to project-specific analysis (e.g. see 2.5.3), but the ready reckoner approach of Table 2.3 can reveal general patterns.

In the absence of definitive data on the level of additional payments needed to entice land managers to enrol, a threshold value of £10 ha/yr has been used for illustrative purposes here, with cells meeting this level highlighted in bold.[62] Cells with negative (red) values indicate that funding under the Code would not even cover its own deductions, and hence is not applicable. The illustrative results imply that the circumstances under which net carbon funding could provide the desired annual payments (i.e. at least £10 ha/yr) to land managers are limited. In particular, the low emission savings offered from improvements to the *Modified* Condition Category are too meagre to generate payments even if carbon prices are relatively high and deductions are low. For example, the illustrative £10/ha threshold is only achieved with zero deductions and a carbon price of £12.50t.

For the two *Drained* Condition Category shifts, net funding is possible but only if deductions are low and/or carbon prices are relatively high. For example, achieving £10 ha/yr with a 35% risk buffer on the *Drained* to *Modified* Condition Category requires a carbon price of £10.00/t even if deductions are zero or £12.50 if deductions are £5 ha/yr. The higher emission savings from the *Drained* to *Near Natural* Condition Category improve the outcome slightly, but low deductions and high carbon prices are still generally required. For example, for a 35% risk buffer, a carbon price of £5/t is sufficient if deductions are zero, but this rises to £12.50/t if deductions are £15 ha/yr.

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[58] The categories are (typical emission 'statuses' bracketed): Near Natural (sinks 1.08tCO_2eq/ha/yr), Modified (emits 2.54tCO_2eq/ha/yr), Drained (emits 4.54tCO_2eq/ha/yr $_e$/ha/yr), and Actively Eroding (emits 23.84tCO_2eq/ha/yr). See WP1 report for more details.

[59] Emission differentials used here may be subject to revision. Actively Eroding land is shown as shifting to a modified rather than natural condition, and is thus perhaps a conservative estimate.

[60] These risk buffer levels are similar to those observed under the Woodland Carbon Code and reflect a mix of precision and permanence risks, with 35% being close to the minimum permitted buffer. So long as the Code remains carbon 'oriented' (i.e. investors want to make some sort of carbon statement) then a higher degree of buffering will be required by the market to maintain credibility. It should be remembered however that whilst higher risk buffers reduce funding levels in the short term, if the project out-performs the buffer then the project could attract additional carbon based funding in the future.

[61] Economies of scale will also affect operational deductions. For example, assuming no discounting, a £5000 accreditation fee spread over 50 years would equate to annual payments of £10/ha for a 10 ha site but only £1/ha for a 100 ha site.

[62] £10/ha/yr accords with anecdotal evidence received from some land managers and restoration practitioners. Moreover, since the HLS re-wetting supplement of £10/ha/yr has proved insufficient to enrol much land, matching it with a top-up under the Code seems a reasonable first offer. Other rates (e.g. £5/ha/yr or £15/ha/yr) could be chosen and, although not highlighted, can be inferred from Table 2.3. Appendix 2.4 reviews briefly possible research approaches to establishing the Willingness to Accept (WTA) of land managers and investors' Willingness to Pay (WTP) such that actual payment rates could be calculated and compared to current agri-environment payment ates to estimate required net funding under the Code to entice additional enrolment

Table 2.3 Net additional annual payment (£/ha/yr) available under Code, by shift in Condition Category for different possible annual deductions and different Carbon prices, with a 35%% or 45% risk buffer

		Condition Category shift, Emission Differential (tCO_2eq/ha/yr) & Risk Buffer							
		Modified to Near Natural		Drained to Modified		Drained to Near Natural		Actively Eroding to Drained	
Code deduction (£/ha/yr)	Carbon Price (£/t)	1.46t/ha/yr 45%	35%	2.00t/ha/yr 45%	35%	3.46t/ha/yr 45%	35%	19.30t/ha/yr 45%	35%
0.00	2.50	2.01	2.37	2.75	3.25	4.76	5.62	**26.54**	**31.36**
	5.00	4.02	4.75	5.50	6.50	9.52	**11.25**	**53.08**	**62.73**
	7.50	6.02	7.12	8.25	9.75	**14.27**	**16.87**	**79.61**	**94.09**
	10.00	8.03	9.49	**11.00**	**13.00**	**19.03**	**22.49**	**106.15**	**125.45**
	12.50	**10.04**	**11.86**	**13.75**	**16.25**	**23.79**	**28.11**	**132.69**	**156.81**
5.00	2.50	-2.99	-2.63	-2.25	-1.75	-0.24	0.62	**21.54**	**26.36**
	5.00	-0.98	-0.26	0.50	1.50	4.52	6.25	**48.08**	**57.73**
	7.50	1.02	2.12	3.25	4.75	9.27	**11.87**	**74.61**	**89.09**
	10.00	3.03	4.49	6.00	8.00	**14.03**	**17.49**	**101.15**	**120.45**
	12.50	5.04	6.86	8.75	**11.25**	**18.79**	**23.11**	**127.69**	**151.81**
10.00	2.50	-7.99	-7.63	-7.25	-6.75	-5.24	-4.38	**16.54**	**21.36**
	5.00	-5.99	-5.26	-4.50	-3.50	-0.48	1.25	**43.08**	**52.73**
	7.50	-3.98	-2.88	-1.75	-0.25	4.27	6.87	**69.61**	**84.09**
	10.00	-1.97	-0.51	1.00	3.00	9.03	**12.49**	**96.15**	**115.45**
	12.50	0.04	1.86	3.75	6.25	**13.79**	**18.11**	**122.69**	**146.81**
15.00	2.50	-12.99	-12.63	-12.25	-11.75	-10.24	-9.38	**11.54**	**16.36**
	5.00	-10.99	-10.26	-9.50	-8.50	-5.49	-3.76	**38.08**	**47.73**
	7.50	-8.98	-7.88	-6.75	-5.25	-0.73	1.87	**64.61**	**79.09**
	10.00	-6.97	-5.51	-4.00	-2.00	4.03	7.49	**91.15**	**110.45**
	12.50	-4.96	-3.14	-1.25	1.25	8.79	**13.11**	**117.69**	**141.81**
20.00	2.50	-17.99	-17.63	-17.25	-16.75	-15.24	-14.38	6.54	**11.36**
	5.00	-15.99	-15.26	-14.50	-13.50	-10.49	-8.76	**33.08**	**42.73**
	7.50	-13.98	-12.88	-11.75	-10.25	-5.73	-3.13	**59.61**	**74.09**
	10.00	-11.97	-10.51	-9.00	-7.00	-0.97	2.49	**86.15**	**105.45**
	12.50	-9.96	-8.14	-6.25	-3.75	3.79	8.11	**112.69**	**136.81**

Interpretation: each cell shows how much funding could be generated by restoring from a given condition category to a near natural condition under a particular combination of operational deduction under the Code, carbon price and risk buffer. For example, restoring from modified to near natural with a 45% risk buffer, a carbon price of £2.50/t and deductions of £0 generates £2.01/ha/yr. Reducing the risk buffer to 35% increases this to £2.37/ha/yr. The equivalent figures for restoring from actively eroding to near natural are £26.54 and £31.36.

Notes: Observed voluntary carbon prices have approached £10/t, particularly for so-called charismatic carbon projects, but are more typically less than £5/t. Accreditation costs under the Code are currently estimated to lie in the £5/ha/yr to £10/ha/yr range and desired profit margins to investors or their intermediaries are likely to be at least £2.50/ha/yr – implying typical operational deductions of £5 to £15/ha/yr. Lower risk buffers may not be credible with investors.

Only for improvements to the Actively Eroding Condition Category are emission savings sufficient to generate significant net funding across the range of carbon prices and deductions considered. For example, even deductions of £20 ha/yr with a risk buffer of 45% still yield annual payments of over £33/ha at carbon prices of £5/t.

In summary, if no operational deductions and a relatively low risk allowance are made, for example if an NGO is prepared to shoulder the administrative costs and forgo any profit, more carbon revenue is available to fund payments to land managers. Under these circumstances, the Code becomes potentially relevant for improvements to all but the *Modified* Condition Category (where emission savings are simply too low to generate sufficient revenue, even at higher carbon prices), but still requires relatively high carbon prices for the two *Drained* condition category shifts. However, if (as seems likely) operational deductions and moderate risk buffers are incurred alongside lower carbon prices, only the *Actively Eroding* Condition Category offers net funding.

2.3.4.3 Cross-subsidisation across condition categories

Although Table 2.3 reports illustrative figures for individual condition categories, many sites and projects will comprise a mosaic of different categories. For example, a small area of bare peat or some dispersed hags and gullies amongst a larger *Drained* or *Modified* area. Hence, in some cases, parts of a given site might generate sufficient net funds whilst other parts might not. Using surplus funding from higher emission categories to cross-subsidise lower emission categories across a site or wider project could increase average top-up payments and potentially enrol more land.[63] Table 2.4 presents some illustrative results for how cross-subsidisation could work using the net funding figures from Table 2.3, reporting the number of hectares (including the originating donor hectare itself) that could be funded from 1ha of a given Condition Category.

The potential for cross-subsidisation is clearly greatest if deductions are minimal and carbon prices high (or if lower top-up payments were considered), but the Actively Eroding category is able to support other land across almost the full range of values considered. For example, in addition to itself, 1ha could cover top-up funding for a further 11.55 ha if there are no deductions, a 35% risk buffer and the carbon price is £10/t; 2.31ha if deductions are £20/ha with a 45% risk buffer and the carbon price is only £5/t.

Condition Category shifts involving the *Drained* category can also support cross-subsidisation in some cases, but much more modestly. For example, 1ha of *Drained* to *Modified* can support a further 0.63ha of other land if there are no deductions, a 35% risk buffer and the carbon price is £12.50/t. However, more generally, the scope for cross-subsidisation is limited – as indicated by the high proportion of cells with values less than 1 (a proportion that increase for a higher payment rate target).

Table 2.5 presents data from Table 2.4 in a slightly different form, focusing solely on the area of each other Condition Category that could be supported by surplus funding from one donor hectare of Actively Eroding land. (Other condition categories are not reported since the scope for cross-subsidisation is so limited). For example, 1ha of *Actively Eroding* land could support 1.85ha of *Modified* to *Near Natural*, or 1.93ha of *Drained* to *Modified* or 2.13ha of *Drained* to *Near Natural* land at a carbon price of £2.50/t with no operational deductions and a 45% risk buffer; 4.71 ha, 4.86ha, or 5.26ha if the carbon price was £5/t.

Given that each site will have its own mosaic comprising condition categories in different proportions, it is impossible to tabulate all possible permutations for actual cross-subsidisation. Nevertheless, the implications are fairly clear in that the Code's potential ability to fund a site (or package of sites) with mixed condition categories will be enhanced if it has a relatively large area of Actively Eroding land. Provided that operational deductions are low and carbon prices high, a site (or package of sites) with a

[63] Bundling of different items into a package deal is common across various markets, for example combined phone-broadband-TV offerings.

large area of *Drained* land may also be able to cross-subsidise other land. This does, however, assume that buyers will be interested in funding (and land managers in offering) more than just the high-emission saving land – implying perhaps a need for explicit conditionality to oblige enrolment of a mix of categories and/or appropriate marketing to extol the virtues of wider restoration (e.g. possible biodiversity gains from restoring low-emission sites).

Table 2.4 Maximum area (ha) of land that could be funded from 1ha of each Condition Category shift to achieve an additional annual payment of £10/ha/yr under different possible annual Code deductions and different Carbon prices, with a 35% or 45% risk buffer.

		Condition Category shift, Emission Differential (tCO_2eq/ha/yr) & Risk Buffer							
		Modified to Near Natural		Drained to Modified		Drained to Near Natural		Actively Eroding to Drained	
Code deduction (£/ha/yr)	Carbon Price (£/t)	1.46t/ha/yr 45%	35%	2.00t/ha/yr 45%	35%	3.46t/ha/yr 45%	35%	19.30t/ha/yr 45%	35%
0.00	2.50	0.20	0.24	0.28	0.33	0.48	0.56	**2.65**	**3.14**
	5.00	0.40	0.47	0.55	0.65	0.95	**1.12**	**5.31**	**6.27**
	7.50	0.60	0.71	0.83	0.98	**1.43**	**1.69**	**7.96**	**9.41**
	10.00	0.80	0.95	**1.10**	**1.30**	**1.90**	**2.25**	**10.62**	**12.55**
	12.50	**1.00**	**1.19**	**1.38**	**1.63**	**2.38**	**2.81**	**13.27**	**15.68**
5.00	2.50	-0.30	-0.26	-0.23	-0.18	-0.02	0.06	**2.15**	**2.64**
	5.00	-0.10	-0.03	0.05	0.15	0.45	0.62	**4.81**	**5.77**
	7.50	0.10	0.21	0.33	0.48	0.93	**1.19**	**7.46**	**8.91**
	10.00	0.30	0.45	0.60	0.80	**1.40**	**1.75**	**10.12**	**12.05**
	12.50	0.50	0.69	0.88	**1.13**	**1.88**	**2.31**	**12.77**	**15.18**
10.00	2.50	-0.80	-0.76	-0.73	-0.68	-0.52	-0.44	**1.65**	**2.14**
	5.00	-0.60	-0.53	-0.45	-0.35	-0.05	0.12	**4.31**	**5.27**
	7.50	-0.40	-0.29	-0.18	-0.03	0.43	0.69	**6.96**	**8.41**
	10.00	-0.20	-0.05	0.10	0.30	0.90	**1.25**	**9.62**	**11.55**
	12.50	0.00	0.19	0.38	0.63	**1.38**	**1.81**	**12.27**	**14.68**
15.00	2.50	-1.30	-1.26	-1.23	-1.18	-1.02	-0.94	**1.15**	**1.64**
	5.00	-1.10	-1.03	-0.95	-0.85	-0.55	-0.38	**3.81**	**4.77**
	7.50	-0.90	-0.79	-0.68	-0.53	-0.07	0.19	**6.46**	**7.91**
	10.00	-0.70	-0.55	-0.40	-0.20	0.40	0.75	**9.12**	**11.05**
	12.50	-0.50	-0.31	-0.13	0.13	0.88	**1.31**	**11.77**	**14.18**
20.00	2.50	-1.80	-1.76	-1.73	-1.68	-1.52	-1.44	0.65	**1.14**
	5.00	-1.60	-1.53	-1.45	-1.35	-1.05	-0.88	**3.31**	**4.27**
	7.50	-1.40	-1.29	-1.18	-1.03	-0.57	-0.31	**5.96**	**7.41**
	10.00	-1.20	-1.05	-0.90	-0.70	-0.10	**0.25**	**8.62**	**10.55**
	12.50	-1.00	-0.81	-0.63	-0.38	**0.38**	**0.81**	**11.27**	**13.68**

Notes: as per Table 2.3. Ha calculated simply by dividing corresponding cell figure in Table 2.3 figure by £10. Area that can be supported in addition to itself is the cell value minus 1. A value of 1 or less (shown in red) indicates that cross-subsidisation is not possible

The potential for cross-subsidisation is not necessarily restricted to annual payments. Rather, instead of presenting annual incentive payments, the scenarios in Table 2.3 can also be used to calculate potential funding under the Code for upfront expenditure. If it assumed that there are no annual incentive payments and if financial discounting is ignored, the figures in Table 2.3 can simply be multiplied by the length of project (e.g. 30 or 50 years) to approximate upfront funding.

Unsurprisingly, the pattern is the same as Table 2.3 (so is not shown here) with the most significant funding restricted to shifts from the *Actively Eroding* Condition Category or to those shifts involving the *Drained* category with low deductions and higher carbon prices whilst the *Modified* category generates funding under very limited conditions. Hence cross-subsidisation would again largely be driven by the Actively Eroding land, although the need for capital funding would also vary across different condition classes.

Table 2.5 Maximum area (ha) of additional land that could be cross-subsidised from 1ha of *Actively Eroding* land to achieve an additional annual payment of £10/ha/yr, by Condition Category under different possible annual deductions and different Carbon prices, with a 35% or 45% risk buffer. Emission differentials are taken from Table 1.9 of this report.

		Condition Category shift, Emission Differential ($tCO_2eq/ha/yr$) & Risk Buffer							
		Modified to Near Natural		Drained to Modified		Drained to Near Natural		Actively Eroding to Drained	
Code deduction (£/ha/yr)	Carbon Price (£/t)	1.46t/ha/yr 45%	35%	2.00t/ha/yr 45%	35%	3.46t/ha/yr 45%	35%	19.30t/ha/yr 45%	35%
0.00	2.50	**1.85**	**2.37**	**1.93**	**2.46**	**2.13**	**2.70**	-	-
	5.00	**4.71**	**5.75**	**4.86**	**5.92**	**5.26**	**NA**	-	-
	7.50	**7.56**	**9.12**	**7.79**	**9.38**	**NA**	**NA**	-	-
	10.00	**10.42**	**12.49**	**NA**	**NA**	**NA**	**NA**	-	-
	12.50	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	-	-
5.00	2.50	**0.85**	**1.37**	**0.93**	**1.46**	**1.13**	**1.70**	-	-
	5.00	**3.71**	**4.75**	**3.86**	**4.92**	**4.26**	**5.40**	-	-
	7.50	**6.56**	**8.12**	**6.79**	**8.38**	**7.39**	**NA**	-	-
	10.00	**9.42**	**11.49**	**9.72**	**11.85**	**NA**	**NA**	-	-
	12.50	**12.27**	**14.87**	**12.64**	**NA**	**NA**	**NA**	-	-
10.00	2.50	0.00	**0.37**	0.00	**0.46**	**0.13**	**0.70**	-	-
	5.00	**2.71**	**3.75**	**2.86**	**3.92**	**3.26**	**4.40**	-	-
	7.50	**5.56**	**7.12**	**5.79**	**7.38**	**6.39**	**8.10**	-	-
	10.00	**8.42**	**10.49**	**8.72**	**10.85**	**9.52**	**NA**	-	-
	12.50	**11.27**	**13.87**	**11.64**	**14.31**	**NA**	**NA**	-	-
15.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	-	-
	5.00	**1.71**	**2.75**	**1.86**	**2.92**	**2.26**	**3.40**	-	-
	7.50	**4.56**	**6.12**	**4.79**	**6.38**	**5.39**	**7.10**	-	-
	10.00	**7.42**	**9.49**	**7.72**	**9.85**	**8.52**	**10.79**	-	-
	12.50	**10.27**	**12.87**	**10.64**	**13.31**	**11.65**	**NA**	-	-
20.00	2.50	0.00	0.00	0.00	0.00	0.00	0.00	-	-
	5.00	**0.71**	**1.75**	**0.86**	**1.92**	**1.26**	**2.40**	-	-
	7.50	**3.56**	**5.12**	**3.79**	**5.38**	**4.39**	**6.10**	-	-
	10.00	**6.42**	**8.49**	**6.72**	**8.85**	**7.52**	**9.79**	-	-
	12.50	**9.27**	**11.87**	**9.64**	**12.31**	**10.65**	**13.49**	-	-

Notes: as per Table 2.4. Values calculated summing across paired cells in Table 2.4 and subtracting one to cover the donor hectare. NA indicates that cross-subsidisation is not necessary since the Condition Category is self-funding. A red zero indicates that funding is insufficient to support cross-subsidisation, either because the donor cell does not have surplus funds and/or the recipient cell has negative funds that more than offset any surplus.

2.3.4.4 Additionality[64]

The levels of net funding under the Code are likely to be modest relative to observed restoration costs which can range up to several thousand pounds per ha for capital works and a hundred or more per ha for on-going management and income forgone. Certainly, in almost all cases, they will be insufficient to fund restoration without support from other sources – most obviously water companies and public sector budgets. Hence, the Code should be viewed as facilitating top-up payments to land managers, not substituting for existing funding.

However, to be eligible under the Code, gross private funding has to account for at least 15% of total funding at a given site.[65] Meeting this additionality criterion may be challenging since it depends on both cost structures and carbon revenues. For example, expensive-to-restore sites may incur substantial capital costs that even the carbon revenues from high emission savings cannot match proportionately. Equally, the revenues from lower-emission saving categories may also be insufficient even if capital costs are also lower.

The additionality position is further complicated by the need to also account for on-going payments. Typically, such payments are made on the basis of estimated averages rather than actual costs incurred (indeed part of the rationale of the Code is the need to top-up on-going payments to cover this perceived shortfall). When aggregated over the life of a restoration project, such payments can be substantial - particularly if income forgone is significant.

Table 2.6 presents the maximum combined (i.e. Code and any other source) funding permissible for upfront expenditure once account has been taken of on-going payments (but not Code deductions or risk buffers since additionality is calculated on gross funding). A 30 or 50 year project is assumed, without financial discounting.[66]

As with the top-up payments in Table 2.3, the figures in Table 2.6 vary considerably across the four condition categories as well as with carbon prices and on-going payments. As before, bigger values are generated by higher emission savings, lower on-going payments and higher carbon prices. Extending project length from 30 to 50 years also increases maximum upfront funding. For example, from £730 to £1217 for 1 ha of *Modified* land with a carbon price of £2.50 and no on-going payments.

With the exception of the *Actively Eroding* Condition Category, negative figures become common as on-going payments rise. Moreover, even where positive, the upfront funding indicated may not be adequate to cover actual expenditure in many cases. That is, without high carbon prices and/or low on-going payments, the applicability of the Code under high upfront costs on low-emission-saving condition categories may be limited.

[64] This report is examining the role of the Peatland Code in attracting private investment and does not consider whether or not providers of public funding are also seeking additionality.

[65] This applies where Corporate Social Responsibility or carbon mitigation are the motivators. However, if there is already a sufficient business case to support restoration - for example based on improving water supplies alone – then the 15% criterion becomes superfluous.

[66] Since the actual capital costs at a given site are unknown, rather than assume particular values such that Code funding could be reported as a % in the Table, results are shown as maximum upfront funding compatible with carbon revenue and on-going payments from other sources. Maximum funding can then be compared with anticipated capital costs typical of a particular condition class.

Table 2.6 Net maximum capital payment (£/ha) under additionality criterion, by Condition Category for different possible on-going payments and different Carbon prices, for a 30 or 50 year project

		Condition Category shift, Emission Differential (tCO_2eq ha/yr) & Risk Buffer							
		Modified to Near Natural		**Drained to Modified**		**Drained to Near Natural**		**Actively Eroding to Drained**	
On-going payment (£/ha/yr)	Carbon Price (£/t)	1.46t/ha/yr		2.00t/ha/yr		3.46t/ha/yr		19.30t/ha/yr	
		30 yr	50yr	30yr	50yr	30yr	50yr	30yr	50yr
0	2.50	**730**	**1217**	**1000**	**1667**	**1730**	**2883**	**9650**	**16083**
	5.00	**1460**	**2433**	**2000**	**3333**	**3460**	**5767**	**19300**	**32167**
	7.50	**2190**	**3650**	**3000**	**5000**	**5190**	**8650**	**28950**	**48250**
	10.00	**2920**	**4867**	**4000**	**6667**	**6920**	**11533**	**38600**	**64333**
	12.50	**3650**	**6083**	**5000**	**8333**	**8650**	**14417**	**48250**	**80417**
40	2.50	-470	-783	-200	-333	**530**	**883**	**8450**	**14083**
	5.00	**260**	**433**	**800**	**1333**	**2260**	**3767**	**18100**	**30167**
	7.50	**990**	**1650**	**1800**	**3000**	**3990**	**6650**	**27750**	**46250**
	10.00	**1720**	**2867**	**2800**	**4667**	**5720**	**9533**	**37400**	**62333**
	12.50	**2450**	**4083**	**3800**	**6333**	**7450**	**12417**	**47050**	**78417**
80	2.50	-1670	-2783	-1400	-2333	-670	-1117	**7250**	**12083**
	5.00	-940	-1567	-400	-667	**1060**	**1767**	**16900**	**28167**
	7.50	-210	-350	**600**	**1000**	**2790**	**4650**	**26550**	**44250**
	10.00	**520**	**867**	**1600**	**2667**	**4520**	**7533**	**36200**	**60333**
	12.50	**1250**	**2083**	**2600**	**4333**	**6250**	**10417**	**45850**	**76417**
160	2.50	-4070	-6783	-3800	-6333	-3070	-5117	**4850**	**8083**
	5.00	-3340	-5567	-2800	-4667	-1340	-2233	**14500**	**24167**
	7.50	-2610	-4350	-1800	-3000	**390**	**650**	**24150**	**40250**
	10.00	-1880	-3133	-800	-1333	**2120**	**3533**	**33800**	**56333**
	12.50	-1150	-1917	**200**	**333**	**3850**	**6417**	**43450**	**72417**
240	2.50	-6470	-10783	-6200	-10333	-5470	-9117	**2450**	**4083**
	5.00	-5740	-9567	-5200	-8667	-3740	-6233	**12100**	**20167**
	7.50	-5010	-8350	-4200	-7000	-2010	-3350	**21750**	**36250**
	10.00	-4280	-7133	-3200	-5333	-280	-467	**31400**	**52333**
	12.50	-3550	-5917	-2200	-3667	**1450**	**2417**	**41050**	**68417**

Notes: as per Table 2.3. On-going costs comprise any annual payments from non-Code sources. For upland sites, on-going payments are typically around £40/ha; for lowland sites, around £160/ha. No Code deductions or risk buffer is applied, meaning that additionality is calculated using gross funding under the Code.

However, as with the additional annual payments, cross-subsidisation across Condition Categories on a given site will be possible[67] – reinforcing the point that the Code is likely to be most applicable to sites with some Actively Eroding land. Consequently, although it needs to be checked on a site-by-site basis (i.e. high on-going and upfront costs may cause problems) and is more certain with higher carbon prices, the 15% additionality funding criteria does not appear to be a barrier to enrolment under the Code. Proving additionality for projects already in place prior to applying to the Code or where the private business case is already strong may be more of a problem.

[67] The financial tool spreadsheet does this, but (as with Tables 2.4 & 2.5) a crude approximation can be attempted here by summing across the values in a given row. For example, if capital expenditure on 1ha of Actively Eroding land was £3000, this would release a potential surplus of £4250 to spread across other condition categories for a 30 year project with a carbon price of £2.50 and on-going payments of £80/ha/yr.

However, although relaxation of additionality criteria to ease access to potential PC funding may seem superficially attractive, adherence to robust additionality criteria will be essential to maintaining confidence amongst many potential buyers– not least since the WCC already has such criteria and is gaining traction in the market place as a result of official endorsement of its rigour. The need for additionality is clear for investment buyers requiring reassurance that what they are buying will have a resale value, but additionality is also a requirement for buyers not necessarily seeking to trade carbon credits. Specifically, any buyer (or donor or sponsor) desires some confidence that their additional funding has enabled (or will enable) more to be achieved than would otherwise have been possible (i.e. that additional funding has made some difference relative to the counterfactual situation). This becomes particularly important if alternative investment/CSR options are available via the WCC or established assurance standards.

The same applies to the requirements for risk buffers and monitoring activities, although in these cases there may be some scope for revising current criteria on levels and intensities if scientific evidence can justify varying them across different Condition Categories. For example, the effects of grip blocking on drained land may be more certain and require less monitoring than re-vegetation of severely eroded land – so different default risk buffers and monitoring processes might be appropriate.

As an aside, the choice of values to use in the financial additionality calculation is not necessarily clear. For example, if an NGO absorbs organisational costs under the Code to maximise the proportion of carbon revenues passed to land managers, how should the NGO resources expended be accounted for? As resources gained under the Code or as non-Code resources? The distinction matters in terms of the additionality proportion generated. Similarly, how should Pillar I support under the CAP be treated? If paid through Pillar II, CAP funding is accounted for, but not if through Pillar I. Yet if eligibility for Pillar I payments was lost under restoration (e.g. under new minimum activity thresholds) and the resulting private opportunity cost compensated via increased Pillar II funding, it would be.

2.3.4.5 Potential Enrolment

If wider applicability of the Code is dependent on using *Actively Eroding* land to cross-subsidise other condition categories, some crude estimates of the area that could potentially be enrolled can be made to establish if this is a constraint or not.

For example, for England, the reported area[68] of blanket bog that is Actively Eroding (i.e. bare peat or hags and gullies) is approximately 53,000 ha. The gripped area (taken here to be equivalent to the two *Drained* condition categories) is 74,000 ha whilst improved grassland, semi-natural habitat and rotationally burned moorland account for 191,000 ha (taken here to be equivalent to the *Modified* Condition Category). At the national level, this implies ratios between the condition categories of approximately 1.4:1 for *Drained* relative to *Actively Eroding* and 3.6:1 for *Modified* relative to *Actively Eroding*.

Comparing these ratios with the cross-subsidy ratios in Table 2.4 suggests that the total area of Actively Eroding blanket bog in England would be sufficient to cross-subsidise enrolment of most if not all areas of the other condition categories of blanket bog. This suggests that the need for cross-subsidisation is not a constraint, unless carbon prices are very low and/or operational Code deductions are very high. Raising the level of top-up payments above the £10 ha/yr used here would, however, at some level eventually impose some restrictions on the scope for cross-subsidisation.

[68] See Natural England (2010) England's peatlands: carbon storage and greenhouse gases (NE257). http://publications.naturalengland.org.uk/publication/30021 Similar, indeed possibly more accurate, mapping exercises are currently underway in Scotland and Wales.

In practice, individual sites will not have the national average ratio between different condition categories and not all lower-emission land will be able to be matched with *Actively Eroding* land. Moreover, at least some of the *Actively Eroding* area may already be under some form of restoration and thus ineligible for funding under the Code. Consequently, the results should be treated as indicative estimates of potential supply-side of enrolment for blanket bog in England. Other types of peatland, such as raised bogs or lowland fens, may have different proportions of each Condition Category – as may blanket bogs in other parts of the UK.[69]

Moreover, actual enrolment is also likely to fall below the upper-bound estimates for a variety of other reasons. For example, some sites will fail the additionality criterion whilst others may simply be unattractive to private investors. There may also be practical capacity constraints in that the availability of specialist restoration equipment and skilled staff is limited and not all sites can be restored simultaneously. Importantly, reliance on other funding sources to cover most upfront capital costs and on-going costs means that enrolment under the Code is contingent on the availability of and compatibility[70] with such funds, such as the size of agri-environment scheme budgets.

Finally, there are demand-side constraints in terms of the willingness of investors to provide sufficient funding to achieve the top-up payments sought by land managers and the ability of project developers to present potential projects in a way likely to secure the necessary funding (for example, in terms of packaging projects to investors, providing guidance on UK government rules and regulations around carbon and environmental claims, and providing continued follow up support). Indeed, there may be a marketing challenge in interesting both buyers and land managers in restoring anything other than *Actively Eroding* land since that is where the dramatic gains and carbon values lie – meaning that different condition categories need to be packaged (i.e. sold and managed) jointly with a degree of conditionality attached to enrolling *Actively Eroding* land.

The actual level of top-up payments required to entice enrolment is also unknown. Although the illustrative figure of £10 ha/yr used here may be plausible, it is possible that higher (or lower) incentive payments would be needed: doubling payment rates to £20 ha/yr would reduce (but not eliminate) the scope for cross-subsidisation. There is also an issue of how best to communicate the realities of restoration to land managers to inform their willingness-to-accept payments and encourage enrolment.

For example, land managers' perceptions of the costs of restoration may be inaccurate – particularly with respect to income forgone incurred through the displacement[71] of current land use activities and/or funding.[72] Public sector bodies and NGOs have a role to play here, to raise awareness and entice enrolment to create a supply of restoration benefits to offer to investors.

Public sector bodies and NGOs may also have a role to play in stimulating demand, by raising awareness amongst potential investors of the Code and what it offers. However, experience with the Woodland Carbon Code suggests that even with a dedicated, specialist intermediary acting as a broker between potential buyers and sellers, the illiquid nature of the market and the site-specific nature of projects often necessitate protracted, bespoke negotiations. Consequently, notwithstanding the potential supply of land from land managers willing to enrol under the Code, demand-side constraints may well limit actual enrolment to significantly less than the upper-bound estimates implied above.

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[69] For Scotland, Actively Eroding land may account for c.34% of the blanket bog area (pers. comm. SNH, 2014), in which case cross-subsidisation would cover the remaining condition classes.

[70] e.g. because the same carbon can't be sold twice, some agri-environment funding may not be suitable for co-funding purposes.

[71] For example, lower stocking densities and/or lower productivity per head due to diseases.

[72] Anecdotal evidence suggests that, whilst the reality is as yet unclear, a perceived risk of losing eligibility for Pillar I payments under the Common Agricultural Policy (CAP) - namely the Basic and Green payment successors to the Single Farm Payment – has dissuaded some land managers from enrolling in restoration.

2.3.4.6 Enrolment case study: The Woodland Carbon Code

History

The WCC could be seen as a useful means of testing the potential enrolment of peatland restoration in the Peatland Code, and in section 2.2.5 there was some discussion of how the WCC works and how it has performed since launch in 2011. There are similarities between the two Codes in that both involve activities that require a long term land use change (or semi-permanent in the case of woodland creation), that are subject to public co-funding via agri-environment schemes, and that would entail an assessment of cost and opportunity cost before participation. It is useful to speculate how much woodland creation could be said to have been driven by the development of the WCC.

As at 31st March 2015 there were 100 projects accounting for just over 3,300 ha of woodland creation validated under the WCC[73]. Many of these projects were implemented before the existence of the WCC – having been validated retrospectively – and so the three year life of the WCC is not an accurate timescale to assess likely annual impacts. The majority of the 3,300 ha (70%+) was created by one business specifically founded to develop and sell carbon credits from UK woodlands – Forest Carbon Ltd – and as this business was actively promoting the creation of something like the WCC in discussions with the Forestry Commission from its inception the planting could be said to have been driven by its possible advent. There are a further 12,100 ha awaiting validation; the significant majority (90%+) of this latter figure is due to the Scottish Forest Alliance (SFA) – a joint venture comprising BP, Forestry Commission Scotland, RSPB and Woodland Trust – that has been working on large scale woodland creation for multiple social benefits since 2000. It cannot be assumed that the WCC was a driving force in this activity as its inception came so far in advance of the Code, although the carbon reductions themselves may have been a driver for BP (statements on the SFA website were unclear on this).

Based on the information above we can be certain that the carbon 'market' has been a driver in at least somewhere in the region of 2,300 – 3,300 ha of woodland creation since 2002 (the earliest planted WCC validated project), and perhaps as much as much as 15,000 ha, with the former case being mostly down the existence of a dedicated woodland carbon project developer, and the latter also including the actions of a single multi-national.

The future

Looking to the future, Figure 2.1 shows the years of planting and validation of all validated projects. Very crudely it could be said that an average of 10 projects have been implemented per annum, at an average size of 36 ha, leading to 360 ha of new woodland each year. There appears to be no increase in the rate of planting of new carbon woodlands since the launch of the WCC, but there are several factors at play here that may have slowed things down, and in any case there has been a Code-related increase in investor interest, and an improved 'sales conversion' rate. Factors slowing new planting include (a) the availability and sale of WCC credits from 'older' woodlands (in itself a potential indicator to the PC of the consequence of certifying projects already implemented), (b) the sometimes long timespans involved in implementing new woodlands, and (c) uncertainties and hiatuses in UK wide woodland creation grants in 2014 (set to be resolved in 2015, although with uncertain outcomes).

[73] By comparison, around 4.5kha across 105 sites have been enrolled in Scotland via the Peatland Action Fund this year (pers. comm. SNH, 2014) – giving some indication of the relative difficulty of securing enrolment with and without the need to negotiate with buyers as well as (land manager) suppliers.

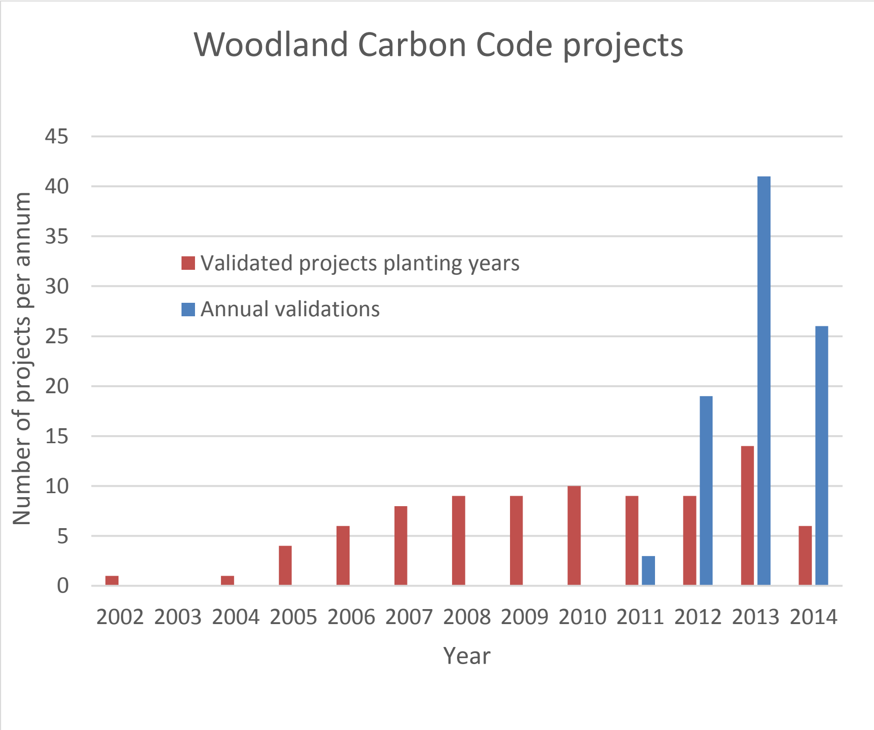


Figure 2.1 Woodland Carbon Code – dates of planting and validation

Outside of the marketing efforts of the main project developer, WCC credits could be said to have joined the mainstream in 2013 with 5 of the main offset retailers exploring partnerships with UK WCC project developers, and two actual partnerships launching (The CarbonNeutral Company with Forest Carbon, and Climate Care with The Woodland Trust). The CarbonNeutral/Forest Carbon partnership has had some success in 2014 in both reaching existing CarbonNeutral partners and also in opening up new partnerships. This does suggest an appetite for UK projects in businesses that are carbon aware.

Woodlands and peatlands in competition?

Early participants in the UK forest carbon market could describe that market as pioneering, and as such the absence at the time of an independent quality assurance standard was not an immediate obstacle, particularly when it became clear one was under development. As far as peatlands are concerned however, the benchmark has now been set by the WCC and it could be that a Peatland Code of at least equivalent status and assurance (ISO accredited, Defra carbon reporting approved, Markit Registry members – all achievable with sufficient time and resource) becomes necessary, as peatland restoration could be in competition with woodland creation (analogies can be drawn here with quality assurance across a range of products and services initially giving a competitive advantage to early adopters but later becoming the industry norm). Figure 2.2 shows an assessment of the possible competitive positions of the two Codes

Figure 2.2 SWOT analysis of Woodland and Peatlands as voluntary carbon tools

Strengths

Peatlands

- Potential scale – could be much greater than woodland creation
- Offers multiple benefits to society (but perhaps fewer than woodlands?)
- Has the ability to deliver immediate carbon savings (via avoided losses)
- There are a range of project developers (environmental NGOs, and water companies) already operating with all the necessary skills for implementing projects describing their benefits and monitoring their success
- Many areas of bog in possibly 'friendly' ownership – not economically driven

Woodlands

- WCC is a full quality assurance regime meeting national and international carbon project standards
- WCC integrated into UK government corporate carbon reporting guidance
- WCC recognised under PAS2060
- WCC credits listed on leading international carbon registry
- WCC has momentum, and (for now) the financial backing of the Forestry Commission
- Offers multiple (and obvious) benefits to society
- Many projects will be accessible to communities
- Projects can be implemented in any part of the country
- Easy to engage investors and stakeholders in visits and activities
- Project carbon profile is a good fit for Zero Carbon Homes requirements
- Can co-exist with productive woodlands – a good sustainability story, and a potentially significant part of the enticement to landowners for enrolment

Opportunities

Peatlands

- The sheer size of the potential UK voluntary carbon market – up to 550mtCO2/yr– and the wide understanding in business and society of the carbon footprint
- If the difficulties of achieving fully accredited status for the carbon market are too great then there is an opportunity in the CSR/sponsorship realm
- More integrated government policy (e.g. Zero Carbon Homes allowing PC projects as allowable solutions)

Woodlands

- Immediately able to capitalise on existing and emerging government carbon policy, e.g. Zero Carbon Homes may include WCC credits
- Offers obvious benefits for other possible ecosystem services markets, e.g. biodiversity offsetting, water management
- The sheer size of the potential UK voluntary carbon market – up to 550mtCO2/yr – and the wide understanding in business and society of the carbon footprint
- More integrated government policy (e.g. Zero Carbon Homes allowing WCC credits as allowable solutions)

Weaknesses

Woodlands

- Not (yet) a full offset – requires nuanced language
- Long timescales – does not offer immediate carbon neutrality, and does not create 'reportable' carbon for up to 15 years
- Relatively low voluntary carbon price means reliance in part on other sources of project funding likely to continue

Peatlands

- Projects may be less accessible to investors and their stakeholders
- It may be more difficult to find meaningful on-site participation activities for stakeholders
- Many projects have complicated land ownership and access rights
- The Peatland Code is a number of years away from achieving the full carbon project quality assurance status of the WCC Relatively low voluntary carbon price means reliance in part on other sources of project funding likely to continue

Threats

Woodlands

- Pests and diseases
- Climate change
- General economic sentiment

Peatlands

- Climate change
- Many projects already implemented will not qualify under additionality rules
- General economic sentiment

2.3.4.7 Discussion

The numerical analysis presented here is illustrative in nature, reporting possible outcomes under different combinations of parameter values. Nevertheless, the quantitative figures align with less-formalised qualitative observations about the applicability of the Code under different circumstances.

- **The scope for the Code to enrol additional land into restoration is highly contingent on the continuing availability of other funding sources** – most notably public budgets and water companies. That is, private funding attracted through the Code may be sufficient to facilitate top-up incentive payments to land managers but not to generally replace more substantial existing payments. It is also worth noting that it is possible for such other funding to be sufficient in many cases to disqualify projects from the Peatland Code under additionality rules.

- **The potential for the Code to fund additional incentive payments is highly dependent on anticipated carbon prices, emission savings and any operational deductions under the Code** (including upfront as well as annual accreditation fees). Although higher prices may be possible, the widespread availability of alternative carbon-saving projects on the voluntary market means that the scope for achieving any premium is likely to be limited: observed prices in the voluntary carbon market are typically too low to generate adequate additional net funds where emission savings are small. In practice, viability of Code funding at a particular site will often rest on the amount of land in the *Actively Eroding* Condition Category and the scope for it to cross-subsidise land falling into other Condition Categories. However, this reliance on cross-subsidy across condition categories need not limit enrolment, provided that land of different Condition Categories can be enrolled jointly under the Code (which reinforces the role of intermediaries – whether NGOs or private brokers – in finding and persuading investors to support packages of different condition classes rather than simply the most attractive land).

- **Although land in the *Modified* Condition Category will probably always require cross-subsidisation, land in either of the *Drained* Category Condition shifts could also generate its own net funding if deductions from gross funding under the Code can be minimised** (which will also increase revenue from the *Actively Eroding* class). In particular, if the costs of annual monitoring/accreditation and margins to investors or market intermediaries can be lowered. In practice, it is not clear how low such deductions can go without adversely affecting the demand-side for the Code. For example, private investors require some assurances about what they are buying – including affirmation that projects will be monitored and managed into the future to achieve objectives – and the process of negotiating site-specific investments necessarily entails transactional effort that has to be resourced somehow; this all becomes more necessary if there is a need to secure higher carbon prices and/or financial recognition of non-carbon benefits. Equally, although some private investors may have no profit motive, securing the level of resources needed to meet the ambitious restoration targets will probably require attracting some profit-motivated investors, meaning that Code deductions cannot be eliminated.

- Care has to be taken to observe additionality criteria. Where substantial upfront capital expenditure and/or on-going payments have been funded from other sources (e.g. for fencing, re-vegetation, high opportunity costs etc), even significant carbon revenue may not amount to 15% of total funding. **More commonly, pre-existing restoration projects or projects with a strong private business case will struggle to demonstrate additionality**.

The Peatland Code has been designed to attract additional private funding to restoration efforts in the UK. The ready-reckoner analysis reveals that only land offering high emission savings is likely to generate significant net funding. Consequently, although ways to reduce risk buffers and operational deductions should be explored to improve the position of all condition categories, only *Actively Eroding* land is likely to support restoration directly.

This suggests two ways to deploy funding attracted via the Code:

- "Surplus" net funding generated from restoring *Actively Eroding* land could be used to cross-subsidise restoration of other condition categories. This would spread the direct influence of the Code across a larger area, but would be dependent on buyers' willingness to fund less dramatic restoration as well as actions on *Actively Eroding* land. It would also be contingent on the availability of other funding sources to cover most upfront and on-going costs - meaning that limited public budgets would still be a constraint. However, demonstrating additionality might be relatively easy in that enrolment in current restoration (as opposed to maintenance) measures within agri-environment schemes is low and additional annual top-up payments to land managers could be sufficient to entice greater participation across the extensive *Modified* and *Drained* categories.

- Code funding could be retained solely on *Actively Eroding* land to provide not only annual top-up payments but to also contribute to funding upfront and on-going costs that would otherwise be funded from other sources. This might be easier to market to some buyers and could, albeit indirectly, still increase the total area under restoration by releasing public funds for deployment elsewhere. However, demonstrating direct additionality might be harder than under the first approach since in this case the additionality will be found in the publicly funded projects happening elsewhere.

In practice, some combination of these two approaches might be possible - varying across different buyers and different sites. The potential for a given project will depend on the level of net funding achievable but also on the type and nature of restoration required in terms of capital works but also on-going payments. For example, some sites may have relatively low capital costs and low on-going costs (e.g. no income forgone) for which Code funding alone might be sufficient, but others will not.

2.3.4.8 Conclusion

As a means of enlarging the area of peatland under restoration, the Peatland Code seeks to attract private finance to supplement existing funding sources. The level of gross funding attracted via the Code will depend on investors' willingness to pay for anticipated benefits accruing from restoration, primarily emission savings (although non-carbon benefits may also influence funding). The additional net funding available to land managers undertaking restoration depends on the expected emission savings, the carbon price used to value emission savings and any risk buffers and deductions incurred through operating under the Code.

Although high carbon prices and low deductions to land mangers might be desirable, observed prices, expected risk buffers and likely operational deductions imply that significant net funds will probably only be generated from land in the *Actively Eroding* Condition Category. As such, to allow for cross-subsidisation to other condition categories, the Code is most likely to be applicable to sites (or projects encompassing multiple sites) where the *Actively Eroding* category accounts for a reasonable proportion of the total area.

Reliance on cross-subsidisation from *Actively Eroding* land need not be a barrier to enrolment, provided that investors can be persuaded to support a degree of cross-subsidisation. Equally, additionality should not be a general constraint, unless restoration has already commenced or the private business case is compelling. However, practical capacity constraints could potentially restrict enrolment as are the realities of market-matching between buyers and sellers in the voluntary carbon market. Nevertheless, the Code does have the potential to contribute to enlarging the area under restoration – although this is highly contingent on the continued availability of other funding.

This potential can be enhanced through actions on both the demand-side and the supply-side. Specifically, since higher carbon prices (or rather simply higher valuations, which could include non-carbon benefits) directly increase funding under the Code, efforts to target and attract particular private investors may be merited - although the availability of alternatives on the international voluntary carbon market is likely to limit the scope for premium pricing. Equally, operational deductions under the Code need to be minimised, to pass a greater proportion of gross funding onto land managers. At the same time, increased payments courtesy of funding under the Code need to be accompanied by awareness-raising amongst land managers of the realities of restoration in terms of both the revenue possibilities but also the costs incurred and on the ground constraints imposed. The field protocols and financial tool developed through the 'metrics' project will help in this regard, but active advisory and facilitation support will still be needed.

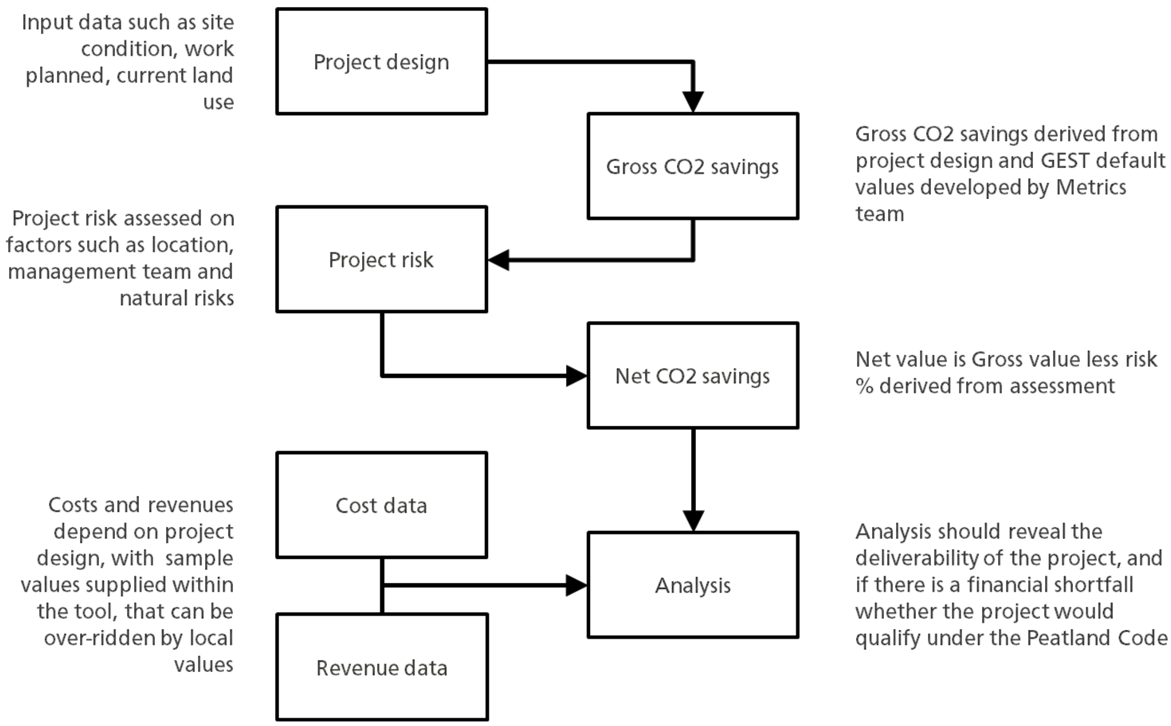
Estimating likely enrolment is essentially a speculative exercise. However, as discussed above, the net funding derived from *Actively Eroding* land should be sufficient to support cross-subsidisation of substantial areas of other condition classes at reasonable payment rates (subject to sufficient public funds being available to cover most costs). As such, the binding constraint is more likely to be the rate at which peatland packages can be designed and marketed to target investors. Experience with the Woodland Carbon Code suggests that enrolment of even a few hundred hectares per year would be a notable achievement, although more could perhaps be achieved if marketing efforts were increased. At this level, it is unlikely that scarcity of specialist equipment and personnel would constrain enrolment. However, experience in Belarus[74] shows that several thousand hectares per year can be enrolled with private funding supplementing public support – although this appears to have been achieved with significant Government and NGO facilitation. If repeated here, this scale of activity could potentially encounter practical capacity constraints.

[74] See Tanneberger, F. & Wichtmann, W. (Eds, 2011) Carbon credits from peatland rewetting. Schweizerbart Scince Publishers, Stuttgart.

2.3.5 Three hypothetical restoration scenarios

2.3.5.1 The Peatland Code Project Financial Feasibility Tool

Figure 2.3 Feasibility Tool flowchart



A Project Financial Feasibility Tool was developed by the authors as part of the work for this report (see Appendix 2.3 for more details and the Financial Feasibility Tool). The Tool is designed to enable project developers to understand the viability of specific projects in terms of (a) testing whether they can demonstrate additionality and (b) then producing a possible carbon price to assess whether the market will accept it. The Tool uses default costs and revenues based on UK wide research, but these values can be over-ridden with local data where available. Figure 2.3 shows how the Tool works.

The Tool was used to assess three typical scenarios put forward by the Metrics work package, and using the Condition Categories developed for that package (Table 2.7).

2.3.5.2 Condition Category definitions (from Field Survey Protocol)

Actively Eroding

- Actively eroding hag/gully system (most of their length having no vegetation in gully bottoms with steep bare peat "cliffs") – emissions of 23.84tCO_2eq/ha/yr.
- Extensive continuous bare peat (e.g. peat pan)
- Extensive bare peat at former peat cutting site

Drained

- Within 30m of an artificial drain (grip) - – emissions of 4.54 $tCO_2eq/ha/yr$.

Modified

This category can be split into two further categories (which will help to inform management/restoration plan) although both will have the same *Modified* emissions factor - 2.54$tCO_2eq/ha/yr$.

Moderately degraded

- *Infrequent fires*
- *Grazing and trampling impacts localised and infrequent*
- *Sphagnum in parts*
- *Extent of bare peat limited to small patches*
- *Scattered patches of Calluna vulgaris*

Highly Degraded

- Small discrete patches of bare peat frequent (micro-erosion)
- Frequent fires
- Frequent and conspicuous impacts of grazing/trampling
- No/little Sphagnum
- Large extensive areas of bare peat
- *Calluna vulgaris* extensive

Near Natural

- Sphagnum dominated
- No known fires
- Grazing and trampling impacts scare or absent
- Little or no bare peat
- *Calluna vulgaris* absent or scarce
- Emissions of 1.08$tCO_2eq/ha/yr$.

2.3.5.3 Scenarios and discussion

Table 2.7 Scenarios tested with Financial Feasibility Tool

	Actively Eroding Scenario	Raised Bog Scenario	Gripped Scenario
Areas and actions	• Shifting 50 ha from *Actively Eroding* to *Drained* with re-seeding • Shifting 1 ha from *Actively Eroding* to *Drained* with gulley re-profiling • Shifting 49 ha from *Drained* to *Modified* using grip blocking • All areas are accessible by machinery • Livestock excluded already	• Lowland raised bog • Shifting 100 ha from *Drained* to *Modified* • Never been planted for forestry • Scrub clearance needed on 30 ha • Not grazed • Some peat dams needed and large drains need to be blocked	• 100 ha upland, shifting 100 ha from *Drained* to *Near Natural* • Small standard drains to be dammed with peat • Standard drain density, • Not grazed, no grouse management, no designations
Costs	• Re-seeding £250/ha • Fertiliser/lime £1700/ha • Brash £1700/ha • Small grips £7.50/dam • Re-profiling £500/ha • Opportunity cost of £20/ha/yr on *Drained/Modified* land	• £400/wooden dam • Small grips £7.50/dam • Scrub clearance £2,000/ha at years 0, 5, and 10 • Opportunity cost of £20/ha/yr on *Drained/Modified* land	• Small grips £7.50/dam • Re-wetting £10/ha/yr • Opportunity cost of £20/ha/yr on *Drained/Modified* land
Project risk	40%	40%	40%
Total project cost	£343,888	£401,521	£218,170
Net CO2	32,469	6,000	10,380
Funding shortfall (15% min)	100%	100%	100%
Required £/tCO2	£10.59	£66.92	£21.02

Assumptions

Assumptions are outlined below:

- All scenarios will seek to gain Peatland Code certification, and therefore will require ongoing monitoring, maintenance and re-certification for 50 years. Code costs are estimated to be £2,500 per project for initial certification, and £950 per project per year for all ongoing monitoring, maintenance, management and re-certification costs (split approximately 50/50 between Code costs and maintenance costs.

- Management time is deemed to be non-trivial and is included (i.e. it is not absorbed as an overhead by developer) – although some NGO developers will wish to absorb this overhead and not include it in the price it is nonetheless important that they are (a) aware of what impact it has on prices, and (b) investors are aware that the developer has resourced the project appropriately to ensure its long term security. It is also the case that for many projects grant funding alone may be sufficient to achieve land use change – e.g. with NGO or public landowners.

- All scenarios are without grants – the grant situation is unclear at present, and in any case may not provide income security over a sufficient term (i.e. the Code requires 30 years plus).

- Landowners require payment of £10/ha/yr (over-and-above on-going cash and opportunity costs) to participate – this is a reflection of the fact that landowners are making a long term commitment, and also that they are likely to be responsible in part for monitoring and managing the projects.

- There is an opportunity cost attached to implementing projects – this is simply a recognition that in many cases current land uses will need to be adjusted.

- Although the NGO landowners/developers might not wish to include either of the above two costs they represent the easiest to access audience for the Peatland Code, and not the majority of projects that will need to be implemented if the Code is to have significant impact.

Grip blocking

- Grip blocking is relatively easy to implement and the skills and materials required vary only slightly across different sites, however it has the dual problem of generating relatively low emission savings (3.46 tCO_2eq/ha/yr if restored to *Near Natural*, 2.0 tCO_2eq/ha/yr if to *Modified*) and being likely to be implemented on land that has some existing economic use – leading to a high carbon price.

- In such cases grant funding (not included here anyway) is unlikely to have a significant impact on the required carbon price as the capital costs are relatively low and revenue grants do not continue for a long enough time to offset landowner opportunity and participation costs. Water company co-funding could resolve these issues as it is not time bounded in the same way, although it would be necessary to demonstrate that the people and restoration work was not already justified by water management cost savings alone.

- Achieving a higher carbon price depends on how receptive target buyers are to the marketing of a particular project, on how well it matches their preferences and elicits a willingness to pay a premium for possible co-benefits such as (e.g.) biodiversity or landscape improvements. A lower risk buffer might be defensible if emission savings from grip blocking have greater scientific certainty and/or the relative simplicity of the grip-blocking techniques reduces delivery risk. However, there is a trade-off here in that buyers' willingness to fund a project is at least partially influenced by how the Code handles risk management and lower risk buffers might dissuade some buyers.

- The same applies to operational deductions in that they too are necessary to ensure market credibility and confidence, and if too low they will be insufficient to support the type of accreditation activities expected by buyers. In any case in this scenario such costs account for around 25% of total cost – which whilst not insignificant would not, by the exclusion, lead to a realistic carbon price in current voluntary market conditions.

Raised bog

- This is by far the most expensive scenario, with capital costs being driven by the need for scrub clearance three times in the first 10 years, and with revenue costs reflecting the likelihood that the land is under economic use.

- The emissions savings are very low in this scenario – only 2.0 $tCO_2eq/ha/yr$ – leading to a very high required carbon price.

- Even in a scenario where there were no opportunity or landowner participation costs the required carbon price would still be significantly higher than present voluntary market conditions would bear, and with scrub clearance accounting for 90% of the capital cost, some sort of capital grant could make a significant difference.

Actively Eroding

- Although this scenario has high capital costs, opportunity costs are reduced by the likelihood that the severely eroded areas (50% of project area) are less likely to be under economic use.

- Because of the high emissions from *Actively Eroding* sites this scenario produces by far the highest emissions savings – 19.3 $tCO_2eq/ha/yr$ – with a corresponding reduction in the required carbon unit price.

- The relatively low required carbon price means that there is a genuine prospect that grant or water company funding could bring the required price of such a project within range of current voluntary market expectations without compromise on either Code additionality or operational costs.

Discussion

In all cases opportunity and landowner participation payments are a significant part of the total cost of the project – ranging from 30% in the *Actively Eroding* scenario to 75% in the Gripped scenario – and this is a good demonstration of scale of funding the Code could be required to generate to overcome landowner inertia.

Given the relative gross carbon valuations attached to restoring the different peatland condition categories, the scenarios would tend to support the ready-reckoner tables (Tables 2.3 to 2.6) in showing that *Drained* and *Modified* projects do not generate sufficient carbon savings to be cost-effective, but also that *Actively Eroding* projects, when combined with grant or water company funding, could generate sufficient funds to cross subsidise these other types of projects, where they also can attract additional funding, through the provision of additional long-term funding that addresses land managers' concerns about the guaranteed duration of agri-environment scheme payments being much shorter than the duration of restoration projects.

2.4 Conclusions & recommendations

Conclusions

The Peatland Code has been designed for the purpose of attracting Corporate Social Responsibility investment into peatland restoration, in an environment where there is no statutory motivator for that investment, and where there are many causes and activities competing for that investment. The ability to measure the climate change benefits of peatland restoration projects is undoubtedly a strong point for the Code, due to corporate and public understanding of the concept of the carbon footprint, and the need for the UK government to take action emissions because of its statutory obligations. This, when combined with the other obvious benefits of peatland restoration, should enable the differentiation of the Code from other CSR activities.

Nonetheless, the Code is likely to operate at the margins: many peatland restoration projects (to date at least) would not have been able to demonstrate additionality due to the receipt of grant and other funding, and at the other end of the spectrum many landowners will not be persuaded to put their land beyond other use for extended periods without significant financial encouragement. This leaves an operational space in between – projects where grant or other funding is insufficient to both achieve and maintain capital works, and to persuade a landowner to proceed. Analysis of varying factors – project costs, project types, landowner behaviour – suggests that the necessary circumstances for projects to qualify under the Code and achieve sufficient carbon savings to generate enough funding to enrol landowners will not cover all types of peatland restoration project. Specifically: severely degraded sites are most likely to meet the circumstances, but conversely may be the most difficult to implement because of the requirement for significant upfront capital funding.

The attractiveness of peatland restoration as a destination for CSR funding is likely to depend on both the charisma of specific projects and their ability to demonstrate to corporate investors that they are solving a problem for or adding value to those businesses. In the light of this, carbon is likely to be a strong suit, as outlined above, and therefore a continuation of progression along the path already followed by the WCC would be desirable. There will also need to be recognition on the part of project developers that engagement with corporates on these projects will take significant time and effort both in the creating of relationships and subsequently in their management.

The Peatland Code has a good comparator in the already existing Woodland Carbon Code (WCC), as both are attempting to incentivise long-term land-use change using voluntary corporate funding. Having achieved fully accredited status and joined a leading global carbon registry the WCC also provides a map should the Peatland Code aspire to achieving the same status.

In the first instance it is useful to take the WCC's achievements since it was launched in 2011 as a simple indicator of likely enrolment under the Peatland Code. A little over 3,000 ha of new woodlands have been WCC certified to date, with a significant majority of the carbon credits generated having been sold. It has taken the existence of a specialist woodland carbon project developer, operating for several years before the WCC's launch, to achieve this figure, but it is possible that peatland restoration, with the weight of the likely participating NGOs behind it (e.g. RSPB) could at least hope to match this level of activity provided there is sufficient understanding of all of this entails.

To achieve significant enrolment the Peatland Code will need to mobilise three distinct groups:

- Project developers (e.g. Forest Carbon Ltd under the WCC) prepared to take resource risks (financial or capacity) in identifying and developing projects, attempting to source investment for them, and possibly in funding them in advance where sales outlets are yet unknown
- Landowners (and their advisers) prepared to sign up to restrictive long-term land-use change, in occasionally complicated ownership and access rights scenarios
- Corporate investors prepared to commit significant upfront funding to projects that may only deliver reportable benefits over a long period

In addition these groups need to overlap, e.g. a willing landowner needs to have a project that a developer is interested in developing and a corporate is interested in investing in. Based on the progress of the WCC to date this is not an insurmountable objective, but does nonetheless highlight the complexities involved and suggests that whilst progress can be made under the Peatland Code it is unlikely to be immediate.

Recommendations

The following work would be useful in exploring further potential for delivering restoration under the Peatland Code:

- Confirmation of emission differentials for the various pair-wise changes in Condition Category;

- Consideration of how operational deductions under the Code could be reduced, without damaging buyer confidence;

- Consideration of whether risk buffers could be reduced and/or varied across different condition categories/restoration activities – again without damaging buyer confidence;

- Clarification of the market-based nature of the Code – i.e. the importance of clear and robust criteria in enabling successful marketing of investments in peatland restoration projects;

- A more rigorous exploration of buyers' willingness to pay for different projects types and configurations (e.g. asking about views on mixes of condition categories, possible co-benefits, etc) – particularly with respect to the circumstances under which a premium (over-and-above carbon price) for non-carbon benefits might be achieved;

- An exploration of the incentives and constraints facing land managers and their willingness to engage in restoration activities (e.g. raising awareness of implications of restoration, discussing desired payment rates etc. – see also Annex IV)

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All links correct as at 28th March 2014

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Appendix 2.1: Domestic policy interaction with carbon markets

Climate Change Act 2008

The Climate Change Act created a framework to deliver, in an economically viable way, on legally binding emissions reductions targets. The legislation is seen as key in both the U.K.'s domestic action and in its international leadership role on climate change.

Key elements of the act are:

- a commitment to achieve an 80% reduction from 1990 emissions levels by 2050;
- the requirement to set interim carbon budgets until 2050 – aimed at achieving the long-term objective cost effectively;
- the assessment of the risks of climate change to the UK and the creation of a National Adaptation Plan;
- the establishment of the Committee on Climate Change – set up to advise the government on emissions targets and progress in meeting them.

The fourth carbon budget was published in June 2011. It covers the period 2023 – 2027 and commits the UK to emissions reductions of 50% on 1990 levels by 2027. The budget reflects the fact that, although there is a long term 'deadline' of 2050 enshrined in the Act, earlier emissions reductions are much more valuable and cost-effective in the fight against climate change and its impact. A 2013 review[75] of the budget concluded that it should remain unchanged for the time being but hinted at a future tightening of the budget depending on future circumstances (such as fossil fuel prices) and agreement on emissions reduction levels at EU and Kyoto level.

Peatlands are seen by the Climate Change Committee as key in both the mitigation of and the adaptation to climate change in the UK through their role in storing carbon and regulating the supply and quality of drinking water[76]. It is likely that under existing climate change scenarios peatland will degrade more quickly unless action is taken in the short term. At present around 96% of upland peat is not in a good enough condition for it to survive the impact of climate change – leading to significant further loss of CO2 to the atmosphere and negative impacts on water.

The Committee suggests that the benefits of restoration to society outweigh the costs, and that whilst there have been some actions to date to improve peatland management and encourage restoration they are not sufficient to deliver the level of change required. The Committee sets out a clear objective for government to support the area of peatland under restoration through better protection of peatlands and incentivising investment in restoration (for example through the Peatland Code).

The U.K.'s emissions reductions targets are ambitious – indeed the Climate Change Act has been described in one quarter as the most expensive piece of legislation UK history[77] – and there are clear signals about the importance of peatlands in both delivering on those goals and meeting the impacts of climate change. Although this is not transformed into active legislation (e.g. carbon trading for UK non-ETS businesses) there is likely nonetheless to be increasing emphasis on the role of business in investing in UK-based emissions reductions activities.

[75] Committee on Climate Change (2013): *Fourth Carbon Budget Review: 2013 progress report*
[76] Committee on Climate Change (2013): *Managing the land in a changing climate – Adaptation Sub-Committee progress report 2013*
[77] http://www.telegraph.co.uk/comment/9416805/MPs-have-no-idea-what-the-Climate-Change-Act-means.html

Zero Carbon Homes

The UK government's objective is that all new homes should be carbon neutral from 2016 (with new public and commercial properties to follow by 2019). There is a recognition that it will not be cost effective (or even possible) to achieve all of this carbon neutrality on site, and so a range of 'allowable solutions' are under consideration that could provide off-site 'offsets'.

The allowable solutions would be delivered via a fund, paid into by developers on a price of carbon and carbon emissions per annum per m^2 basis, with funding for the first 30 years' emissions paid in at the outset. Various allowable solutions are under discussion – including district heating schemes, retrofitting and renewables – and the forestry industry has been lobbying for the inclusion of Woodland Carbon Code projects in the programme via the Zero Carbon Homes public consultation[78] on the basis that the Code provides UK Accreditation Service (UKAS) audit and there is an obvious synergy between construction and productive forestry.

Zero Carbon Homes could also represent an opportunity for peatland restoration as the absence (so far) of a UKAS audit mechanism is not seen as a hindrance to other potential allowable solutions. The initiative's timeframe is also appropriate for peatland restoration – with up-front funding for 30 years of carbon capture matching the minimum carbon contract length allowable under the Peatland Code.

Carbon Reduction Commitment

The Carbon Reduction Commitment (CRC) is a mandatory pan-UK scheme designed to improve energy efficiency and cut emissions in large public and private sector organisations not already covered by Climate Change Agreements (CCAs) and the EU Emissions Trading System (EUETS). Participants include supermarkets, water companies, banks, local authorities and all central government departments. Organisations qualify if their electricity consumption passes a certain threshold, and they must register with the scheme or face penalties.

Participants must monitor their energy use, convert it to CO2 emissions equivalent and then purchase and surrender allowances to offset emissions. Allowances can be bought at annual fixed-price sales, or traded on the secondary market. One allowance must be surrendered for each tonne of CO2 emitted. The allowance price in Phase 1 has been set at £12 per tonne of CO2.

The scheme will be simplified from 2014, offering greater business certainty, less overlap with other schemes, a 55% reduction in administrative costs and greater incentives to implement cost cutting energy saving measures.

There is an opportunity to lobby for the inclusion of domestic emissions reduction projects, such as those created under the Woodland Carbon Code or the Peatland Code, as a permissible alternative to CRC credits. Such projects represent real emissions reductions and may be more palatable to companies buying credits. The consequence would be a loss of revenue to the Treasury, but this may be more than balanced by the social and economic benefits of local projects. This is not likely to be a near term possibility, but nonetheless is something the Peatland Code developers should consider.

[78] https://www.gov.uk/government/consultations/next-steps-to-zero-carbon-homes-allowable-solutions

Carbon Price Floor

The Carbon Price Floor, which came into effect in April 2013, is a mechanism designed to guarantee a minimum price for carbon emissions used in the generation of electricity – effectively acting as a surcharge on EUETS credits if their current market price is below the price floor. The system is intended to incentivise investment in low carbon technology by providing price certainty (and a price high enough to act as an incentive), and could be said to have arisen because of the low prices prevalent in the EU Emissions Trading Scheme). The stated aim is for prices to rise from £16/tCO2 in 2013 to £70/tCO2 in 2030, although in the 2014 budget the floor was fixed at the 2015/16 rate until 2020[79].

The policy has attracted criticism on the basis that it could make UK business uncompetitive, as the costs of investment or carbon price will be passed on to end users, and that it is unlikely to lead to a reduction in emissions across the EU as it doesn't cause a reduction in the number of EUETS credits available.

Neither the carbon floor price nor the CRC has any immediate impact on the Peatland Code, but both could be useful indicators of what government thinking on the acceptable level of impact of carbon price on business might be.

Natural Capital Committee

Although focussed solely on the natural environment in England, the Natural Capital Committee[80] and the Natural Environment White Paper that created it are nonetheless radical policy initiatives worth noting. The committee reports to the Treasury, not Defra, and is tasked with bringing, for the first time, the value of England's natural capital – that is elements of nature that provide value to society – onto a national balance sheet and with warning the government when natural assets are being used unsustainably.

The Committee will work with various bodies and the research councils to produce an annual State of Natural Capital report, as well as identify appropriate avenues for research, and encourage landowners and businesses to take up natural capital accounting.

Ecosystem Markets Task Force

The Task Force (EMTF)[81] was again brought together as a consequence of the Natural Environment White Paper – this time with a task-and-finish remit to identify the opportunities for UK business in green goods and services. The EMTF submitted its final report in March 2013, concluding that business is often unaware of its true reliance on nature and highlighted opportunities for developing markets and services in:

- the water cycle;
- the food cycle;
- carbon and nature; and
- natural resources – risk and resilience.

[79] https://www.gov.uk/government/publications/carbon-price-floor-reform
[80] http://www.defra.gov.uk/naturalcapitalcommittee/
[81] http://www.defra.gov.uk/ecosystem-markets/

Defra Payment for Ecosystem Services Trials

Ecosystem services could be defined as the using of natural capital to provide goods or services – including carbon capture and flood mitigation by peatland restoration and woodland creation.

Since 2012 Defra has commissioned a range of PES pilot projects to test out practical application and develop proof of concept with the aim of testing how to move from theory to practice. The pilot Peatland Code was developed as one of these pilots.[82]

A review of the Defra pilots was published in October 2014[83].

Biodiversity offsetting

Biodiversity offsetting – also highlighted in the Natural Environment White Paper – is presently being trialled in 6 local authority areas in England on a voluntary basis. Should such a scheme become mandatory peatlands could have a significant part to play, although as of March 2014 no transactions are reported to have taken place[84] and there has been opposition to the programme from various corners[85].

Conclusions

Although not all relevant to peatlands alone, the initiatives above nonetheless demonstrate a clear direction in government thinking that could stimulate more demand for peatland restoration projects through either statute or simple awareness building.

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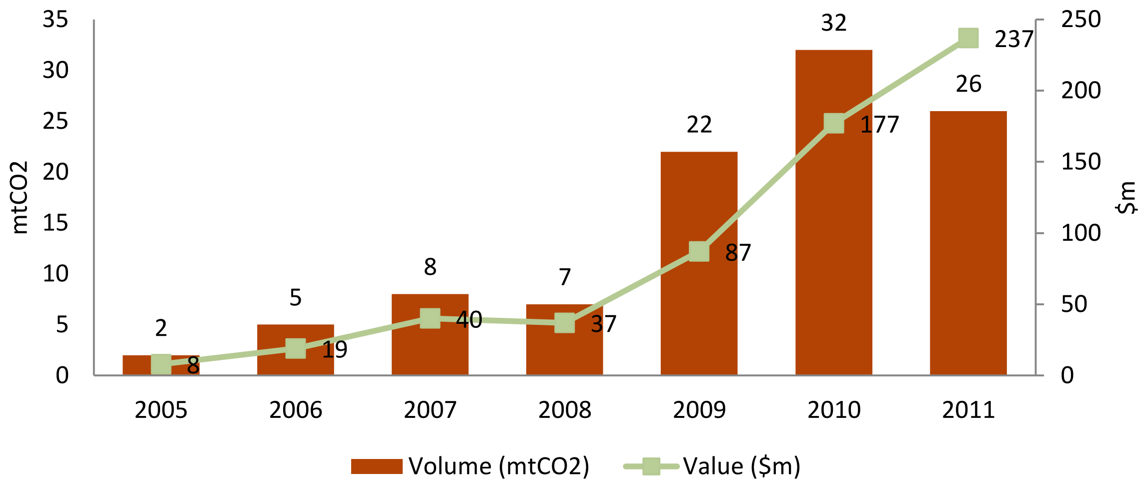
[83] https://www.gov.uk/government/publications/payments-for-ecosystem-services-review-of-pilot-projects-2011-to-2013
[84] http://saveourwoods.co.uk/articles/opinion/biodiversity-offsetting-in-uk-one-year-on-not-looking-good/
[85] http://www.theguardian.com/environment/2014/mar/11/owen-paterson-bidiversity-offsetting

Appendix 2.2: Global voluntary carbon market data[86]

Volume, value and price

Figure A: Forest carbon volume and value 2005 - 2011



Key highlights from 2010 and 2011 are shown in Figure C. The volume data represents only what was transacted in the given year, not the potential total carbon saleable from projects.

Figure B: Volume and price data in forest carbon markets, 2010 & 2011

	Volume (mtCO2)		Value ($ millions)		Average price ($)	
Market	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
Voluntary OTC	27.8	16.7	157.8	172.0	5.6	10.3
California	0.5	1.6	-	13.0	-	8.1
CCX	0.1	0.0	0.2	-	1.2	-
Voluntary total	28.4	18.3	158.0	185.0	5.6	9.2
Kyoto	1.4	5.9	6.3	23.0	4.5	3.9
NSW GGAS	2.3	-	13.0	-	-	-
NZETS	0.2	-	0.3	-	13.0	-
Compliance total	**4.4**	**7.3**	**25.0**	**52.0**	**4.6**	**7.2**
Grand total	**33.0**	**26.0**	**177.0**	**237.0**	**5.5**	**9.2**

[86] Ecosystem Marketplace: (2013): *Leveraging the Landscape: State of the Forest Carbon Markets 2012*

Project types and locations

Figure C: Voluntary market % share project types - 2011

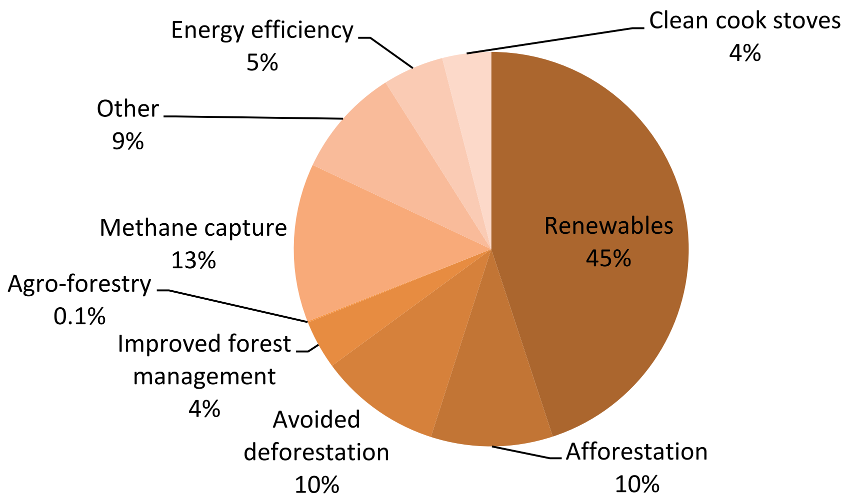
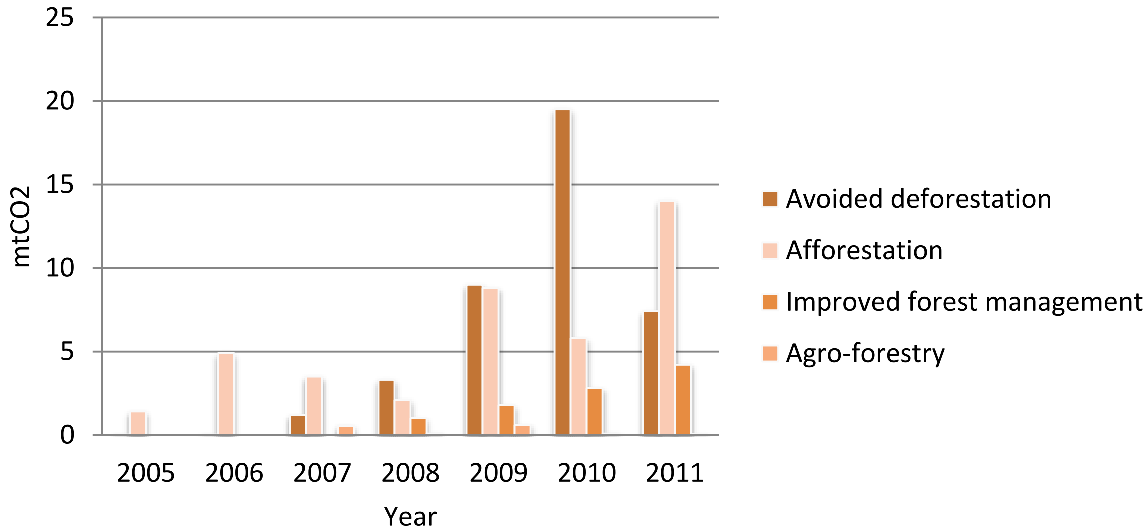
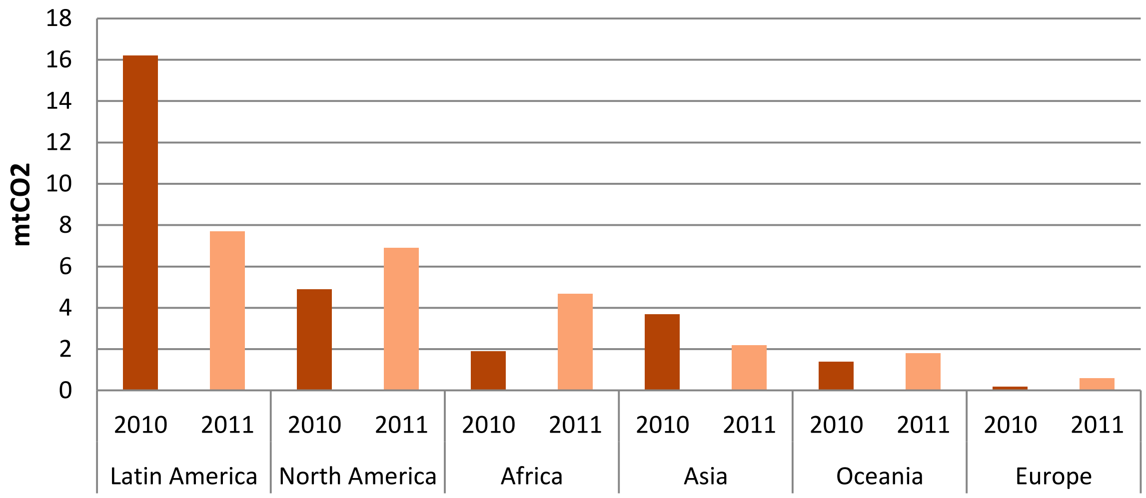


Figure D: Forest carbon project volumes by type and year



Over the period data during which data has been collected avoided deforestation and forest creation have provided a significant majority of projects, with 40 million tonnes transacted each. To put the WCC into context: to date around 0.7 million tonnes have been certified.

Figure E: Forest carbon project volumes by location - 2010 & 2011

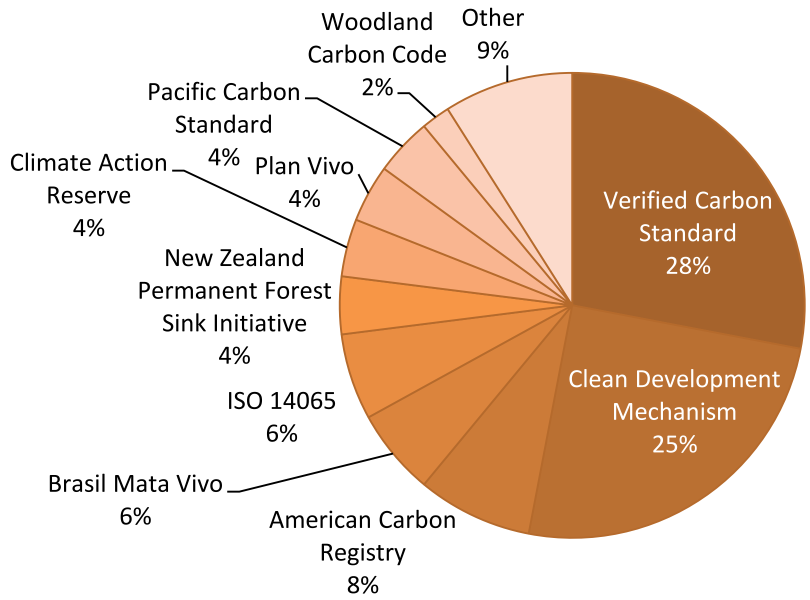


At the time the 2011 data was collected the WCC was in its infancy, with only a handful of projects had been certified, and will not have had any impact on the European data.

Main voluntary standards and activities

Most activity in the voluntary market is certified either to VCS (Verified Carbon Standard – the world's leading voluntary carbon standard) or via the Clean Development Mechanism – one of the Kyoto Protocol's flexible mechanisms, designed to allow the creation of offsets in developing nations, for us in developed nations, via technology transfer. Both of these standards have methodologies that cover forestry projects, and the world's other major voluntary carbon standard – the Gold Standard – has now bought the forest-based CarbonFix standard to move into the forest carbon market. None of these standards is applicable in the UK as all would require credits to be full offsets.

Figure F: Forest carbon standards used by % share - 2011



Buyer categories and motivation

Figure G: Buyer market sectors - 2011

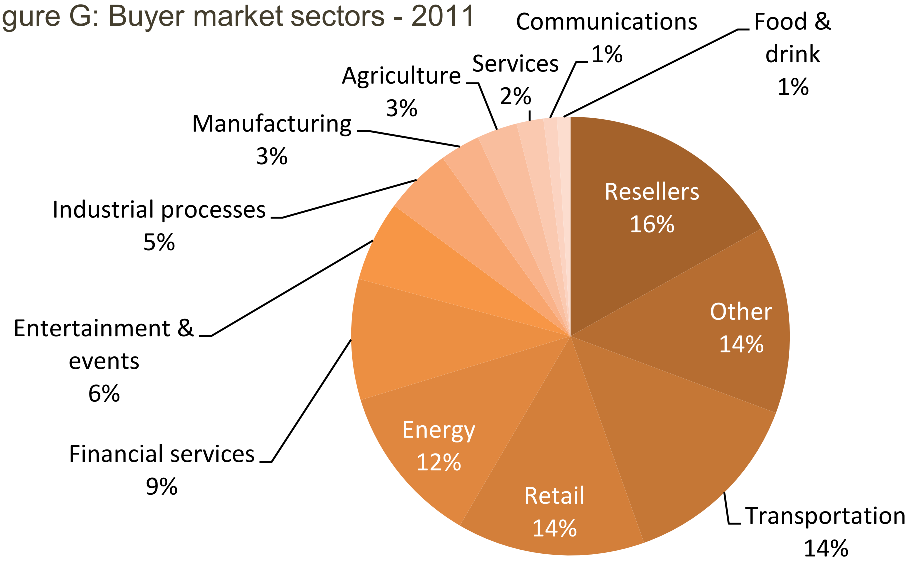
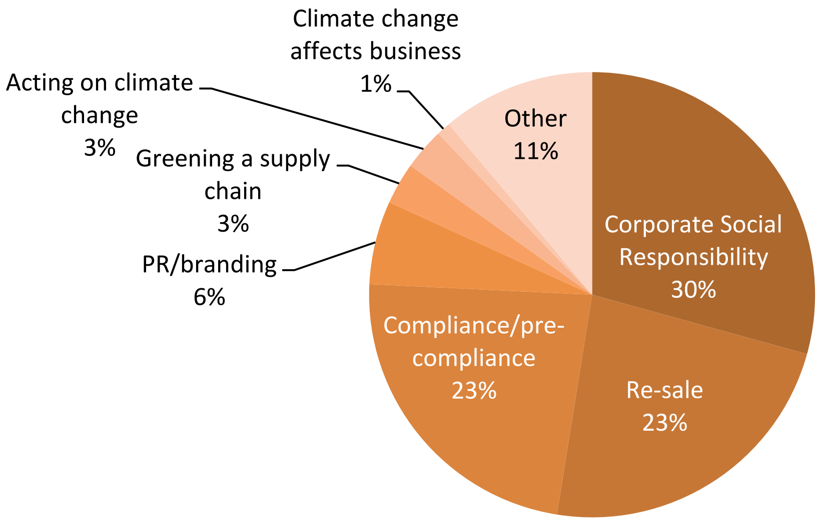


Figure H: Buyer motivation - 2011



Appendix 2.3: The Peatland Code Project Financial Feasibility Tool

The Peatland Code Project Financial Feasibility Tool has been designed to provide a guide for project developers examining the financial viability of peatland restoration projects aimed at generating saleable ecosystem services - in the first iteration this is focussed specifically on generating carbon emissions reductions payments, but the model does not exclude the possibility of a project receiving other sources of ecosystem services revenue.

The assessment of viability is important in two regards:

- deriving a possible price for the carbon emissions reductions generated – in order to assess their attractiveness to the market, and
- demonstrating the additionality of a project – ie that the financial contribution of the carbon (and possibly other ecosystem services) is essential for the project to proceed.

The tool incorporates guide values based on collection of data from:

- a wide range of UK peatland restoration projects, and
- Woodland Carbon Code certified projects (as the UK 'market leader' in certified tradable ecosystem services).

Suggested values are provided to aid the early stages of project development. These values are based on various sources, including existing peatland restoration projects around the UK, Woodland Carbon Code projects, and Agri-environment scheme costs and grants. As a project progresses local data can be applied, but otherwise the suggested values will be applied as a default. Justification for local values should be provided as it would ultimately be required as part of any credible project certification mechanism to prove the additionality case.

This tool has focused on carbon emissions reductions as the primary potential source of ecosystem services revenue because:

- this is at present the best developed ecosystem services market in the UK, and
- this model is being developed to dovetail with peatland carbon assessment tools also under development.

The tool is a spreadsheet and it comprises five areas where data can be entered and one where the results are viewed. In each of the worksheets data may only be entered in the grey cells.

- The 'Project design & development' worksheet is where the specific details for the project at hand are entered, for example: site condition and works required. The sheet also allows users to split the project into different Assessment Units (AUs), with AUs differentiated by condition and work required. This means that, for example, a single geographical site with several different areas of peatland condition and restoration intentions can still be assessed as one project.
- The 'Project costs' worksheet is where individual unit costs are entered. For example costs per metre for fencing, or cost per hectare for forestry removal.
- The 'Project revenues' worksheet is where units for revenue items are entered. Examples may include £/m capital grants for fencing, and £/ha revenue grants for livestock exclusion.
- The 'Project risks' worksheet is where the potential carbon emissions reductions are adjusted for local risk. This worksheet is taken from the Peatland Code and will need to be completed in any case if Peatland Code certification is sought.

- The Emissions calculator worksheet shows the emissions reductions generated based on the project type and condition categories for each AU.
- The 'Outputs' worksheet provides information on the overall financial viability of the project and indicates whether a project could qualify for carbon funding and at what price it would need to sell its carbon to break even.

A project can be comprised of work at more than one physical location, but they should be within a reasonable distance of one another for the project to be cost effective to implement and manage.

Feedback from users involved in current and planned restoration projects has been broadly positive about the Tool, and suggestions for improvements have been incorporated into the latest version.

Appendix 2.4: Approaches to estimating price responsiveness

The material presented here underpins the main text on estimating enrolment, but offers greater detail on approaches to estimating the uptake of restoration activities. The main conclusion is that there are a number of data and modelling challenges to overcome.

Empirical approaches to estimating enrolment responsiveness fall into three main categories.[87] First, insights may be gleaned from observed enrolment patterns under existing schemes, either in previous periods and/or in other locations. For example, reported enrolment in peatland-relevant aspects of the Entry Level (ELS) and Higher Level Schemes (HLS) in England gives some indication of the attractiveness of current payment rates. Specifically, although the level of aggregation masks some detail and there is some double-counting, it is apparent that enrolment is dominated by upland areas.[88]

However, agri-environment schemes generally have uniform payment rates, meaning that observed enrolment typically relates only to a few fixed payment levels rather than a continuum of payment rates necessary to econometrically trace-out a supply curve. As such, it is not possible to identify how much additional land would be enrolled (or withdrawn) if payment rates increased (or decreased) slightly. In principle, if payment rates have varied over time and/or regionally, it may be possible to overcome this estimation problem – and indeed there is some regional variation in payment rates across the UK.[89] However, cross-regional comparisons are hindered by variation in other influences on land use decisions, including single farm payment rules and rates, farm tenure and taxation. Some such differences do exist across the UK, but would be more of a hindrance to cross-EU comparisons.[90]

Separately, whilst peatland-specific schemes are still relatively rare, there is considerable experience with agri-environment schemes more generally and it might be possible to draw some analogies. However, enrolment in most agri-environment schemes is for a comparatively short (e.g. five to ten years) period and management prescriptions (e.g. stocking densities) and their effects are relatively easily reversed, whereas peatland restoration (under the Code) is for a much longer period and some prescriptions (i.e. re-wetting) will be harder to reverse. This suggests that meaningful analogies may be limited, with forestry perhaps being the closest case – albeit that the tax treatment of timber hampers direct financial comparisons, and forests can perhaps more readily generate a range of economic returns even when included in a PE Scheme (e.g. the Woodland Carbon Code allows the inclusion of commercial forestry).

A second approach to estimating enrolment responsiveness is to utilise farm-level financial information gathered through routine and/or bespoke farm surveys. For example, Farm Business Survey data for England have been used to estimate Gross and Net Margins for a variety of farm

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[87] For example, see Suter et al. (2008) Do landowners respond to land retirement incentives? Evidence from the CRP. Land Economics 84/1, 17-30.
[88] See (ECI *et al.,* 2013) Assessing preparedness of England's natural resources for a changing climate: Exploring trends in vulnerability to climate change using indicators. Report to the Adaptation Sub-Committee of the UK Climate Change Committee. http://www.theccc.org.uk/wp-content/uploads/2013/07/TCCC-ADAPT01-12_Final_Report_Revised_v3-without-Appendices_29July13.pdf
[89] See Thorp et al. (2013) Evaluation of measures and policy mechanisms to protect peatland. Report by Scotland's Moorland Forum to SEPA http://www.jottercms.com/files/moorland/130715_SEPA_Peatland_Evaluation_Report.pdf
[90] Although an attempt to estimate aggregate opportunity costs across the EU is presented by Kaphengst et al. (2011) Taking into account opportunity costs when assessing costs of biodiversity and ecosystem action. IEEP report to the European Commission. http://ec.europa.eu/environment/enveco/biodiversity/pdf/OpportunityCostsOfBiodiversityAndEcosystemAction.pdf

enterprises,[91] and these can serve as the basis for estimating the opportunity costs of displacing an activity.

Reported estimates indicate that lowland farming enterprises are typically more profitable than upland ones, and thus confirm that payment rates to enrol lowland peatland sites will be relatively high (because opportunity costs will be higher) whilst more modest rates should be relatively attractive to upland farms. Indeed, many upland farming enterprises appear to run at a loss and thus no (financial) opportunity costs will be incurred even if activities are completely displaced by restoration. Unfortunately, non-agricultural activities such as forestry and grouse shooting are not surveyed routinely in the same was as farming, meaning that estimates of profitability in these sectors are scarcer.[92]

However, the usefulness of national survey estimates is in any case hampered by generally not being tied to specific locations (i.e. peatlands) nor taking account of how compatible an activity might be with restoration (i.e. reported figures give only an upper-bound estimate as if the activity was completely displaced). Moreover, although Net Margins are a first approximation of long-run opportunity costs, no allowance is made for the potential for on-farm adjustments to reduce costs. For example, by using other land, changing enterprise mixes, or altering farming systems. Bespoke local surveys combined with formal consideration of on-farm adjustments can overcome this,[93] but incur additional research effort. In addition, the apparent persistence of loss making activities suggests that financial performance factors are not the sole determinant of land use decisions.

A third approach that potentially addresses some of the problems of the first and second approaches is to directly ask land managers for their willingness to accept (WTA) compensation payments in return for enrolling land in a restoration programme. This avoids trying to infer responsiveness from observed past enrolment patterns or statistical analysis of financial data, but does assume that respondents are sufficiently informed to give accurate answers and are not tempted to exaggerate required payment levels as a negotiating ploy. It also necessarily incurs some additional research effort.

A number of techniques of varying complexity/sophistication have been developed for eliciting WTA. For example, deliberative workshops, contingent valuation or choice experiments, and auctions.[94] Each has advantages and disadvantages, but in general allows for some exploration of how payment rates plus other features of voluntary contracts affect enrolment. For example, length of contract, minimum areas, restrictions on other land use, interactions with other support payments,

[91] See Wilson, P. (2014) Review of Gross and Net Margins and Cost Centre Allocations in the Farm Business Survey. Rural Business Research report, University of Nottingham. http://www.fbspartnership.co.uk/documents/Review_of_Gross_and_Net_Margins_and_Cost_Centre_Allocations_in_the_FBS.pdf

[92] For example, vague categories are reported for forestry by Vanguelova et al. (2012) A Strategic Assessment of Afforested Peat Resources in Wales and the biodiversity, GHG flux and hydrological implications of various management approaches for targeting peatland restoration. Report by Forest Research staff for Forestry Commission Wales Project, with Reference No 480.CY.00075 (T), October 2012. http://www.forestry.gov.uk/pdf/Peatland_Wales_Report_2012.pdf/$FILE/Peatland_Wales_Report_2012.pdf; for grouse shooting, figures have to be inferred from sources such as PACEC (2006) The economic and environmental impact of sporting shooting. A report by Public & Corporate Economic Consultants to BASC, CA, and CLA and in association with GCT http://www.shootingfacts.co.uk/pdf/pacecmainreport.pdf

[93] For example, see Parsisson, D. et al. (2000), 'Switching to area LFA payments for livestock: Some post-Agenda 2000 modelling results for the North Pennines, England', Farm Management, vol.10, no.9, pp. 515-523 and Armsworth et al. (2012) The cost of policy simplification in conservation incentive programs. Ecol. Lett. 15,406–414. doi: 10.1111/j.1461-0248.2012.01747.x

[94] For example, see Broch, S. & Vedel, S. (2012) Using Choice Experiments to Investigate the Policy Relevance of Heterogeneity in Farmer Agri-Environmental Contract Preferences. Environmental and Resource Economics 51, 561-581.

transaction costs and peer pressure. Unfortunately, although analogies may perhaps be drawn with other agri-environment schemes, peatland-specific applications of such techniques are scarce. Moreover, a recent deliberative workshop confirmed that respondents' awareness of the practicalities and costs of restoration is perhaps currently too low to support robust WTA estimates at present.[95]

Discussion of example data for England

In the absence of detailed, peatland-specific data on variation in opportunity costs across different sites, it is not possible to construct robust estimates of enrolment responsiveness to different carbon credit prices. Nevertheless, it is possible to discuss available information to get a feel for how enrolment might respond and to highlight where further research may be merited.

Table i: Area and proportion of LCM land cover over peatland[96]

LCM land cover	Ha	%
Bog	1732.46	25.71
Arable and horticulture	**1569.98**	**23.30**
Dwarf shrub heath	**1022.78**	**15.18**
Improved grassland	**703.59**	**10.44**
Acid grassland	**678.79**	**10.07**
Coniferous woodland	**334.43**	**4.96**
Montane habitats	287.83	4.27
Broadleaf, mixed and yew woodland	**194.02**	**2.88**
Rough grassland	**131.90**	**1.96**
Neutral grassland	**40.93**	**0.61**
Fen, marsh and swamp	38.17	0.57
Calcareous grassland	3.68	0.05
Not peat restricting	2062.14	30.60
Peat restricting	4676.42	69.40
Total PEAT	**6738.56**	**100**

Values in bold are those classes considered to restrict peat development

Estimating enrolment responsiveness essentially involves assigning opportunity costs to different sites. Although the actual distribution of costs across individual sites is unknown, available information is perhaps sufficient to suggest the main types of activities currently undertaken on peatlands and to suggest typical opportunity costs for different categories.

For example, for England, GIS overlays of peatland areas with the Countryside Survey Land Cover Map and with Agricultural Census data permit approximate apportionment of the total peatland area between different land covers, as shown in the Tables below. These indicate that formal agricultural usage covers perhaps 40% of the total peatland area, but that bog, heath and other grasslands are equally prevalent with woodlands less so. This confirms that restoration programmes

[95] Reed, M. & Kenter, J. (2015) Valuing the Dark Peak. A Deliberative Approach to Payments for Peatland Ecosystem Services. Report on workshop on peatland restoration in the Dark Peak Natural Character Area (NCA 51). Report to Moors for the Future.
[96] Taken from ECI et al. (2013) op. cit. "restrict peatland development" reflects a judgement of whether a land cover is compatabile or not with active formation of new peat.

need to engage with different communities of land managers across farms, sporting estates and forests.

Table ii: Ranked list of farm land use types – June 2010 agricultural census[97]

JAC Code	JAC Variable	On peat (km2)	Arable/Improved grazing/Rough grazing (km2)
total_crops	**Total cropland**	**1460.99**	**1412.33**
total_grass	**Sum of grass sown before and after 2000**	**900.66**	**553.16**
g2	**All other grassland**	**806.68**	**470.24**
a1	**Wheat area**	**552.63**	**536.61**
g5	**Rough grazing**	**354.07**	**104.81**
total_osr	**Total OSR**	**128.47**	**124.79**
a24	Winter OSR	128.47	121.29
a12	**Sugar beet**	**117.79**	**115.09**
g1	**Grass sown in 2000 or later**	**93.98**	**82.93**
b99	**Total vegetables and salad grown in the open**	**93.09**	**90.34**
total_pots	**Total potatoes (early + late)**	**92.93**	**88.55**
total_barley	**Total barley (spring + winter)**	**92.77**	**85.79**
a11	**Late potatoes**	**89.85**	**85.93**
b21comb	All other vegetables and salad	87.28	84.54
a3	Spring barley	52.84	48.49
a2	Winter barley	39.92	37.30
a32	**Bare fallow**	**38.22**	**37.08**
g17comb	**All other land**	**37.24**	**30.22**
g14	**Woodland**	**36.67**	**26.94**
a21	**Field beans**	**36.20**	**35.54**
a22	**Peas for harvesting dry**	**26.48**	**26.36**
a27	**Linseed**	**18.04**	**17.80**
a23	**Maize**	**17.78**	**16.04**
a31comb	**Other crops for non-food use**	**12.51**	**11.37**

Data by farm land use types both for the full coverage of this data within peatlands and for subset within both the peatland mask and the LCM arable mask. Variables in bold are amalgamated variables, variables with non-bold text are sub-variables from which they are derived. Row shading splits data into three classes: green=grassland, orange=cropland, grey=other. Only crops with >10km2 national coverage are included.

Land cover data do not by themselves convey information about the intensity of management, but typical management can be inferred from the land cover categories. In particular, for agriculture, published industry standards offer a benchmark for common practices and profitability of different enterprises whilst the estimated Gross and Net Margins derived from the Farm Business Survey offer insights into variability across farms. Equivalent estimates are not readily available for forestry or for grouse and deer estates, but could be presumably be canvassed from industry sources.

[97] Taken from ECI et al. (2013) op. cit. Last column has smaller area figures as a result of using a more restrictive GIS mask for the extent of peatland.

For agriculture, Gross and Net Margins estimated from the Farm Business Survey in England are presented below for selected enterprises and years. Figures are £/ha or £/head and are given as the reported 95% confidence interval around the estimated mean value. In addition to revealing considerable variation between enterprises, the figures also reveal variation across farms and years within a given enterprise. This highlights the heterogeneity issues encountered in trying to specify opportunity costs in abstract for particular farms or locations.

Table iii: Gross and Net Margins estimated from the Farm Business Survey[98]

Crops	Years					
	2008/2009		2010/2011		2012/2013	
	GM (£)	NM (£)	GM (£)	NM (£)	GM (£)	NM (£)
Winter Wheat	594 to 635	-132 to -74	891 to 949	13 to 78	749 to 799	-164 to -103
Potatoes	1989 to 4421	-127 to 831	3359 to 4752	634 to 1751	4357 to 6120	1057 to 2534
Lowland sheep	33 to 40	-94 to -70	47 to 56	-114 to -79	39 to 64	-133 to -96
Lowland cattle	134 to 235	-440to -372	97 to 147	-588 to -408	158 to 216	-654 to -461
LFA sheep	23 to 42	-102 to -50	30 to 42	-74 to -43	26 to 44	-66 to -45
LFA cattle	101 to 161	-386 to -315	88 to 138	-387 to -280	148 to 230	-400 to -317

Although Net Margins are a better indicator of opportunity costs (i.e. accounting for overheads), it may be that many land managers will themselves use Gross Margins.[99] On this basis, if current activities were to be displaced completely by restoration, compensation payments would (on average) need to be over £600/ha to tempt wheat growers and even higher to tempt potato growers.

For sheep enterprises, it appears that payments of perhaps £40 to £50 would (on average) compensate for displacing one ewe in lowland areas whilst £30 to £40 would perhaps suffice in upland areas. For suckler cow enterprises, £150 to £200 per cow might suffice. Conversion of this to a per ha figure requires further assumptions about stocking densities.

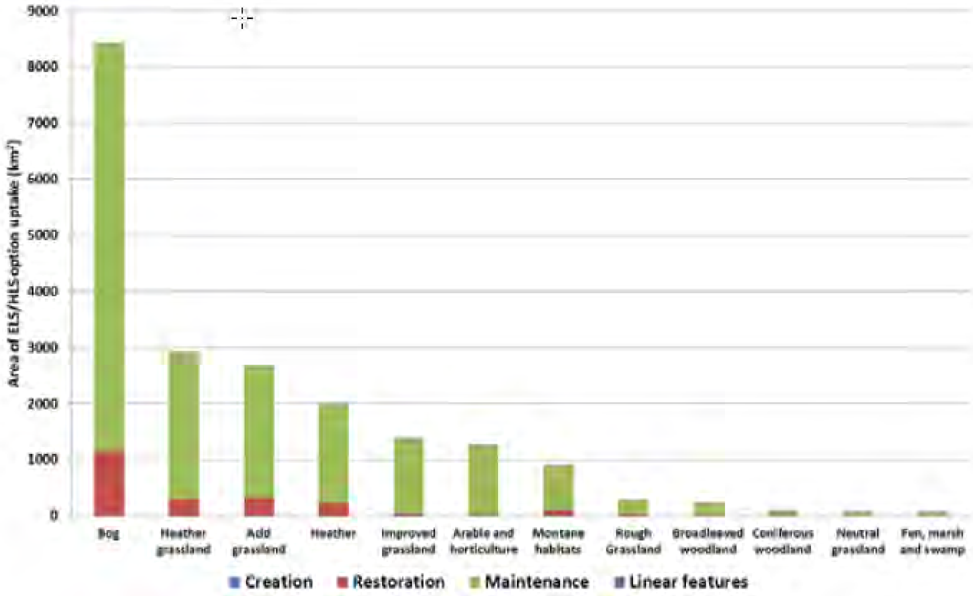
GIS analysis of ELS and HLS data for England shows the extent to which peatland-relevant agri-environmental measures are currently being implemented across different land covers.[100] The graph below shows that overall enrolment is dominated by upland land covers (e.g. bog, heather), with relatively small lowland areas enrolled. Moreover, positive restoration is less common than maintenance activities, despite a supplementary payment being available for rewetting.

This pattern of uptake is not inconsistent with the indicative opportunity costs inferred from the Farm Business Survey. For example, payments in upland areas (e.g. £40/ha/yr for controlled stocking) look reasonable for typical stocking densities and (assumed) minimal displacement. That rewetting is relatively less popular than basic maintenance measures may indicate that the

[98] Wilson (2014) op. cit.
[99] Partly because they may not be aware of their fixed costs, but also because Net Margin calculations invoke some strong assumptions, particularly with respect to how land and other fixed asset values are treated.
[100] ECI et al. (2013) op cit. It is important to note that since some agri-environment measures can be implemented jointly on the same parcel of land, the total area (i.e. height of bar) will exaggerate the actual number of unique ha enrolled. A breakdown by agricultural census land cover is not available, nor the composition of each bar in terms of specific management measures (pers. comm. Robert Dunford, ECI)

additional £10/ha is perceived as insufficient to compensate for further reductions in stocking densities and/or a loss of longer-term flexibility over land use decisions.[101]

Figure i: Area of ELS/HLS uptake on peatland sites by LCM land use[102]



Lowland peat areas are less extensive than in the uplands, but the absolutely smaller areas enrolled under improved grassland and arable/horticulture will also reflect farmers' higher opportunity costs – higher gross margins and a greater degree of displacement. Similarly, the almost complete absence of restoration measures probably indicates perceived additional displacement arising from rewetting. Payment rates in lowland areas are £60/ha to £150/ha (although some higher rates may also apply), sufficient to enrol grazing land but not arable.

Speculatively, the level of funding likely to be gained through voluntary carbon markets under the Peatland Code will probably be insufficient to enrol significant lowland farming areas. That is, although lowland grazing might be amenable, arable production is relatively profitable and would be displaced by any restoration such that overall payment rates need to be considerably higher.

This contrasts to upland areas where extensive grazing is reasonably compatible with restoration and current profitability is low. ELS and HLS enrolment is high, and relatively modest payment increases through carbon funding might be sufficient to convert maintenance-only areas to active restoration.

However, given the persistence of apparently loss making agricultural enterprises – in lowland as well as upland areas – a narrow focus on headline financial incentives may be insufficient as a guide to enrolment patterns. In particular, attention should also be directed to understanding non-financial barriers to uptake (e.g. awareness, peer pressure) and non-financial motivations. The latter may apply to farming, but is also highly relevant to sporting estates.

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[101] This could perhaps be considered using real-options analysis, although data constraints will be problematic.
[102] Taken from ECI et al. (2013) op. cit.

Appendix 2.5: Overview of private costs and benefits of restoration

NB This Appendix was prepared to guide the development of the Peatland Code Project Financial Feasibility Tool and has been included for information.

Introduction

The economic case for restoring degraded peatlands rests on the net value to society of doing so, on the overall difference between the costs of restoration activities and the benefits achieved. Restoration is merited if net benefits are positive (as is generally indicated by most economic analysis[103]).

However, importantly, such public economic analysis takes no account of the distribution of private gains and losses across different groups in society. In particular, that most costs fall on land managers whilst most benefits accrue (diffusely) to other groups. Yet the economic focus remains on the overall net position since *in principle*, even if compensation is not implemented in practice, a net positive value allows those groups gaining to compensate any groups losing.

By contrast, the private business case for a restoration project and for individual land managers choosing to voluntarily restore a peatland site will rest primarily[104] on the balance between actual costs incurred and actual revenue received *by that project and its constituent businesses* as a result of restoration. The broader public case is relevant only so far as it justifies policy measures to share costs more widely through, for example, public subsidies or payments for ecosystem services (PES) as revenue sources to individual businesses.

In addition, for the public economic case, many benefits have non-market values. For example, DECC carbon prices or Willingness-to-Pay (WTP) estimates for biodiversity. Although these are genuine economic values, they do not represent cash transfers between consumers and producers. Hence, again, their relevance to individual businesses is limited to how government supports attempts to convert (valorise) non-market values into actual revenue streams.

Revenue categories

Revenue to land managers engaging in restoration activities falls into three main categories. First, restoration activities may attract government support in the form of grants and subsidies (or indeed tax breaks). These may relate to upfront capital and administrative costs and/or on-going management requirements and income foregone. Payments under CAP Pillar II agri-environment schemes are the most obvious example, but others may be available. Typically, payments are linked to expenditure incurred plus reduced profits arising from lower commodity outputs. Payment rates may be based on actual recorded figures or standard costings (which may be higher or lower than actual costs incurred by an individual land manager).

Second, through development of PES schemes, payments for non-market benefits such as carbon storage and biodiversity enhancement may be available. Although currently limited, these are hoped to increase. Unlike government support funded by taxpayers, payment rates will be determined primarily by market demand for ecosystem service outputs rather than bureaucratic

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[103] See, for example, Natural England (2010), Harlow et al. (2012) and ASC (2013).

[104] Some landowners may have other motivations for restoring peatlands, such as personal preferences or position in the community, but widespread voluntary restoration will require financial incentives – although it is possible that restoration will generate private benefits too (e.g. fencing for stock control).

assessment of their production costs. Importantly, market values are likely to be significantly lower than the non-market values used in economic analysis.

Finally, although not compatible with all other land uses, restoration may be compatible with some commodity production or recreational service provision. For example, extensive livestock grazing, grouse management, paludiculture or eco-tourism. As such, it may be possible to generate market returns, possibly branded as being associated with restored peatlands. However, the presumption here is that such opportunities are likely to be limited.

Importantly, funding from government sources and (especially) via PES schemes is generally conditional on any restoration activities being additional - that restoration would not have otherwise occurred anyway. This requirement for additionality means that, for example, PES funding might not be available to a project already in receipt of grant aid and generating other commercial income. However, the compatibility of different revenue sources under additionality criteria is as yet uncertain and is likely to be judged on a case-by-case basis (for example, the Woodland Carbon Code uses a 15% threshold for PES revenue as a proportion of total costs to judge if the PES achieves additionality).

Separately, although there is a presumption that a project will be developed to merely cover costs, it is possible that carbon credits generated could be subsequently traded at a profit. If permitted under the Peatland Carbon Code, the distribution of such profits between the land managers generating them and the project funders (i.e. PES investors) would be a matter for negotiation. However, it does highlight the need to distinguish between the perspectives of a project developer and of land managers participating in a restoration project – in particular the treatment of carbon payments as a cost to one but revenue to the other.

Revenue data

Government grants and subsidies under a range of restoration schemes are published on relevant websites and are updated periodically. Payment rates and eligibility criteria vary across different schemes and different parts of the UK. However, in general, standard costs for different capital items are used to estimate grant rates for capital expenditure, whilst standardised management and income forgone calculations are used to set on-going payments. For example, Defra's High Level Scheme under Pillar II of the CAP offers up to 100% funding for grip blocking and £40/ha per year for moorland restoration with a further £10/ha annual payment for re-wetting.[105]

Private payments for environmental benefits depend on the estimated magnitude and mix of benefits to be delivered by restoration. In the case of carbon, although government guidance suggests £30/t may be achieved by 2030, market prices are typically in the range of £2 to £15 per $tCO2_{e}$,[106] so a project yielding 2t/ha of carbon benefits would generate £4 to £30 per ha per year, 4t would generate £8 to £60, and so on. The estimated carbon benefits (emission avoided plus any sequestration) will vary with initial conditions of a site, the proposed restoration activities, the assumed counterfactual baseline, and any potential 'leakage' caused by emissions occurring elsewhere as a consequence of the implementation of the restoration – all of which will be specified by the carbon metric protocol. Buffering requirements to reduce investors' risks in relation to permanence and leakage may reduce the effective area paid on.

[105] An unpublished 2013 paper for SEPA by Scotland's Moorland Forum summarised available government payments relating to peatland restoration.

[106] This contrasts markedly with the DECC values of £29 to £86 which reflect social rather than private values and are used in economic analysis.

Figures for the revenue potential of other land use activities are difficult to specify since they are likely to be sensitive to local conditions. For example, on the degree of compatibility with restoration but also the level of demand for products and services. Moreover, income forgone and/or additionality criteria mean that both government grant and PES funding may be reduced if any additional income is derived in other ways from restored land. In such cases, there may be no net gain to a land manager – although there may be some scope for negotiation, especially with respect to PES funding.

In all cases, with the exception of upfront capital costs, some account needs to be taken of how unit costs and prices might vary over the life of the project. That is, both subsidy rates and market values can increase or decrease. In addition, strictly, future revenues (and costs) should be discounted back such that all monetary values can be compared on the same Present Value basis regardless of where they lie on the project's timeline. However, experience with the Woodland Carbon Code suggests that formal price forecasting and discounting are seldom undertaken since the carbon price prevailing at the start of a project is typically used to value all expected carbon saving ex-ante and uncertainty over both the precise magnitude and precise timing of future costs arguably renders discounting an unnecessary complication.

Cost categories

Costs fall into four main categories. First, as with any enterprise, arranging and implementing restoration activities involves organisational and administrative effort – spending time on planning, communication and paperwork. For example, assessing site suitability and resource needs, complying with grant & accreditation criteria, and meeting with local stakeholders.

These *administrative and compliance costs* may occur throughout a restoration project but will typically be front-loaded into earlier years. The more complex a restoration project is in terms of, for example, the number of land managers involved or differences in their attitudes to the project, the greater such costs are likely to be.

Second, not all existing land uses are compatible with restoration. For example, softer and wetter ground conditions may be less suitable for livestock grazing or grouse management. Consequently, existing land uses may be displaced and some income foregone – meaning that an *opportunity cost* will be incurred each and every year.

Opportunity costs depend on both the profitability of an activity being displaced and the degree to which it is actually displaced. With respect to the latter, whilst some land uses (such as peat extraction) may be completely displaced by restoration, others (such as extensive grazing) may be only partially displaced. Hence some activities may be able to continue with management adjustments and/or relocation to other parts of a land holding. In terms of current profitability, care has to be taken to distinguish between revenues and profit. That is, an activity may generate positive revenue but be unprofitable once expenditure is accounted for – meaning that opportunity costs can be very low or even negative in some cases.[107]

Third, restoration typically incurs upfront capital investment. For example, fencing may be required to exclude livestock whilst machinery and materials may be required to block grips and gullies and to stabilise and re-vegetate bare peat. The precise costs incurred vary with the type and degree of degradation being tackled, but will generally increase with the severity of degradation and the

[107] Although non-cash opportunity costs may be incurred, such as through lifestyle changes or loss of visual amenity associated with cessation of (e.g.) keeping sheep or heather burning.

remoteness of (difficulty of access to) a site. Costs for capital works may include non-cash costs of a land manager's own labour input.

Finally, restoration is a process that entails recurrent management and monitoring that incurs on-going costs. For example, to maintain dams, to clear encroaching scrub and to check water levels and vegetation regeneration. Such efforts are not necessarily required every year, but will recur periodically and represent a non-trivial commitment to on-going engagement (and are additional to any opportunity costs which are treated separately).

Government-funded payments often include explicit reference to each cost category. For example, for management plans, in income foregone calculations, as capital expenditure allowances and as recurrent management payments. By contrast, privately-funded payments for commodity outputs or other ecosystem services will be negotiated with respect to costs but also buyers' valuation of outputs. Where PES funding is less than the costs of delivery, some mix of public and private funding will be required. However, in all cases the individual land manager will need to compare costs and revenues to form a judgement on the private merits of restoration.

Cost data

Peatland sites display considerable variation in terms of their size, condition, ownership, management and history. Land-based businesses also display considerable variation in terms of their size, structure, ownership, management and history. Consequently, the costs and benefits of restoration are likely to vary somewhat and local knowledge will be required to undertake a definitive assessment of any given site.

Nevertheless it is possible to specify indicative values for different cost categories, and how they may vary with local circumstances. Such indicative values are drawn from experience reported in the academic and "grey" literature plus from interaction with restoration practitioners involved with various UK projects. In particular, the "compendium" collated by Holden *et al.,* (2008) served as a starting point for recurrent discussions[108] with practitioners that have continued as projects have matured and practical experience has continue to accumulate.
Attempts to collate cost data have revealed considerable variation in reported costs. Some of this reflects variation in the nature of restoration projects in terms of their complexity and ambitions. For example, with respect to the size of a site, its current management and the relative abundance of bare peat, gullies and grips plus the specific restoration techniques adopted and the nature of monitoring pursued.

However, variation in reported costs also reflects a lack of standardisation in measurement. For example, different cost categories are not necessarily reported separately or consistently and, more problematically, calculation of unit costs (e.g. per m or per ha) can be undertaken in different ways. For instance, the per ha cost of blocking grips may be calculated simply by dividing total blocking cost by the total area of the restored site or by a smaller area estimated to be directly affected by the grips (e.g. 10m either side of the grips). The latter approach gives a higher per ha cost than the former, but both have been used in different projects.[109] Further development of the Peatland Carbon Code will include refinements to cost data.

[108] For example, as part of the IUCN UK Commission of Inquiry on Peatlands, through the Valuing Nature Network peatland theme and subsequent development of the draft Peatland Carbon Code, and for the Adaptation Sub-Committee of the Climate Change Committee. Projects reporting cost data stretch from the South West of England, through Wales, the Pennines and North York Moors, to the North of Scotland.

[109] If presented clearly, both approaches are acceptable – but whatever basis is used, the same basis has to be adopted for calculating benefits per ha. That is, if carbon benefits (and thus payments) are expressed on a per ha basis, then the ha calculation has to be the same as used in calculating costs – implying a need for clarity with respect to the condition and density of (especially) linear features present.

For an individual business, the emphasis will be on understanding how individual costs (and revenues) arise and correctly calculating total costs (and revenues). Attention thus has to be paid to carefully describing the basis for calculations, both their categorisation (to avoid double-counting or omission) and the units used (to avoid aggregation errors). The following section outlines initial indicative values for use in a project, whilst Appendix 2.5.1 offers a draft set of questions to help frame restoration decision making and choose appropriate financial values.

Indicative costs

Administrative and Compliance Costs

Administrative and compliance costs are not necessarily cash costs, but instead mostly reflect the time taken to initiate and progress a restoration project. This may include activities such as arranging site surveys, drafting management plans, applying for funding and complying with funding or accreditation criteria – all of which may require bilateral and/or multilateral communication (including meetings) with advisors, sponsors, regulatory bodies and neighbouring land managers/users. The more complicated a restoration project and/or the more sponsors it has[110], the higher the level of administrative and compliance costs are likely to be – although there is probably a minimum level that will be incurred by even small projects.

Reported administrative costs for peatland restoration projects are of the order of £3000 to £6000 at the start, plus £1000/year thereafter. However, these are from the perspective of project organising bodies rather than individual land managers. As such, they probably overstate costs to the latter for whom estimates for analogous farm-level activities may be more relevant. For example, experience with the Woodland Carbon Code or compliance with existing Pillar II schemes. In this context, indicative values of perhaps 5% to 15% of total costs may be appropriate.[111] Actual expenditure may be incurred on activities such as site surveys or drafting of management plans that require some professional assistance - indicative costs of £16/ha for survey work and £800 for management planning are suggested here. In addition, validation under PES assurance procedures may cost up [£700] to [£5000] plus an ongoing cost of £3-£5/ha.

Opportunity costs

Opportunity costs arising from the displacement of existing land use activities will vary across different activities and with local circumstances. Sites with extensive gullies and bare peat are unproductive in terms of agriculture, grouse or forestry and thus restoration is unlikely to incur opportunity costs. By contrast, restoration of less degraded sites used for agricultural, forestry or sporting interests may impose income foregone losses. Although individual land managers are best placed to estimate the profitability of current activities and thus the potential for income foregone, indicative values are suggested below.

Upland agriculture typically takes the form of extensive grazing, the market profitability of which is often very low or even negative. As such, opportunity costs are likely to be minimal. Moreover, if restored sites have a mosaic of vegetative covers and/or managers have access to other land, restoration will not necessarily completely displace agricultural activities. However, if restoration affects eligibility for the Single Farm Payment (for example if open pools of water form), then there will be a revenue loss from some land that needs to be accounted for.[112] Indicative values of zero, £40 and £80/ha/year are suggested here.

[110] For example, if PES funding is layered to different buyers and/or in tandem with public funding.
[111] See, for example, Falconer & Saunders (2002) or Mettepenningen et al. (2009)
[112] In an economic analysis, subsidies are transfer payments and as such would not be included in opportunity costs. However, they are highly relevant to private decision making.

Restoration of afforested peatland sites[113] is incompatible with continued forestry and may incur significant opportunity costs if standing timber is harvested prematurely. That is, if tree growth would continue towards maturity, early harvesting foregoes the value of that additional timber. The magnitude of this opportunity cost will depend on how premature harvesting is, the assumed price of timber and the species and yield class of the trees.[114] For some sites, the yield class may be very poor and/or harvesting impractical – meaning that opportunity costs will be minimal. For other sites, yields may be reasonable and opportunity costs significant. Indicative values of zero, £100 and £370 per ha per year of early harvesting are suggested here, the latter based on yield class 10 and a price of £14/m^3 felled.[115]

The compatibility of restoration with grouse management is still subject to debate. Reductions in the frequency of burning and wetter conditions may or may not lead to fewer grouse. If restoration does reduce grouse numbers, this will translate into lower revenue. However, since the profitability of grouse shooting is not reported with the same rigour as agricultural or forestry enterprises, it is not clear whether this also implies foregone income - anecdotally, many grouse enterprises lose money and are supported by private transfer payments from estate owners. Indicative values of zero, £20/ha and £100/ha are suggested here.

Capital costs

Some restoration activities will incur no capital costs. For example, reductions in the frequency of heather burning or reductions in the number of grazing livestock. However, most restoration activities will require some upfront capital investment. For example, most simply, permanently excluding grazing animals may require fencing, for which standard costs have been long been established for other agri-environment and forestry schemes. Indicative values of £4.5 to £10/m are suggested here.

Other capital costs are less-well documented and relate more directly to altering peatland surfaces. In particular, to blocking grips and gullies in order to reduce drainage and raise water levels, and to re-vegetating bare peat or clearing scrub and trees in order to achieve an appropriate vegetative cover. In all cases, remote sites pose additional problems in terms of access. Although this hinders all restoration activities, it is particularly problematic if specialist machinery and significant quantities of materials are required to combat extensive bare peat or severe gullies. In such cases, additional costs are incurred through recourse to laborious ground transport or quicker delivery by helicopter.

Grips-blocking is a common and relatively simple restoration technique. Essentially, it involves placing a dam across the grip to hamper drainage and raise water levels. For larger grips, the dam may be a plastic or wooden insert or (for dry conditions) heather bales. For smaller grips, peat collected from the surrounding area and compressed into a dam will normally suffice. Depending on the cross-sectional shape and size of the grip, it may be necessary to reprofile it to dam more effectively. Depending on the local topography, the recommended distance between dams along a grip is 7.5m (5m to 12m), with steeper slopes requiring more frequent dams to reduce overspill.

[113] Such sites may perhaps not be suitable for peatland PES support, not least since accounting for timber-carbon is not necessarily straightforward, but are included here for completeness. Extension of PES to lowland bogs would require consideration of arable land uses (Grave & Morris, 2013).
[114] See, for example, Vanguelova et al. (2012) and Morrison (2013).
[115] Strictly, account could be taken of the possibility to continue with another forestry rotation, but it is assumed here that guidance on afforestation of peatland sites will make this unlikely.

Indicative values of £0.95/m are suggested for blocking with peat dams, or £1.80/m with reprofiling. Larger grips and gullies tend to require reprofiling at £2.50/m, with plastic dams costing £2.50 each, heather bale dams £6 to £38, and wooden dams £40 to £70 (if larch) or £150 to £300 (if oak).

Re-vegetating bare peat can involve stabilisation of the surface, using geotextiles or heather brashing, to combat further erosion and improve conditions for germination. Indicative costs are £9000/ha to £12000/ha for geotextiles or £1700/ha to £4500/ha for brash delivered by ground and helicopter respectively. Brash cut on site costs £1500/ha. Seeds or actual plants are also required, with indicative costs of £250/ha for seed or £4000/ha for plug plants. Depending on the desired vegetation type, it can also involve the application of lime and fertiliser, costing £400/ha (repeated once) and £225/ha (repeated twice) respectively.

Clearing existing land cover can be expensive, particularly clear felling standing timber. However, if timber was due to be harvested anyway, the additional costs of clearing for restoration purposes will be minimal. Separately, if harvesting is impractical due to access problems and/or timber is too low in value to merit removal, it may be appropriate to leave trees standing or to leave felled trees in situ. Indicative values of £0/ha to £5000/ha are suggested here.

On-going management costs[116]

On-going management of restored sites may be necessary to maintain capital works. For example, repairing fencing and dams – although, unless they fail soon after installation, the latter tend to be relatively resilient. In addition, combating scrub encroachment may be required, either through mechanical removal or targeted grazing (which may incur minimal additional cost if livestock are already present). Indicative values of £5/ha to 10/ha/year are suggested here.

Reported monitoring costs vary considerably, but are often significant, running into hundreds if not thousands of pounds. This reflects the fact that the type of intensive and sophisticated measurement of water quality and ecological conditions undertaken by projects is often expensive, requiring specialist equipment and staff. Even public agency costs for designated sites such as SSSIs are around £40/ha/year. However, it is unlikely that individual land managers will be required to meet such standards but will focus instead on simpler indicators such as water levels or vegetative cover that can be observed more readily. As such, individual monitoring costs are expected to be lower (and some possibilities are being explored as part of the Metrics work). Indicative costs of [£4/ha] and [£10/ha] per year are suggested here - although there is a potential overlap with annual PES assurance activities.

Summary

This short overview has attempted to sketch-out the sources of costs and revenues that a project developer or individual land manager should consider when deciding whether or not to restore a peatland site. The indicative values suggested in relation to various costs are offered to allow some worked examples, but should be subject to further scrutiny. In particular, the extent to which different categories of peat are present as a mosaic across a site needs to be accounted for since (e.g.) relatively scarce parcels of high-cost bare peat may generate higher unit revenues but are likely to contribute less in aggregate terms than low-cost/low-revenue parcels requiring simple grip blocking. However, care should be taken to not over-complicate assessments since initial site surveys are not costless and, moreover, the underlying science may not necessarily support fine sub-divisions of peatland categories.

[116] Management and monitoring will not typically be required each and every year, but costs are averaged across all years.

Appendix 2.5.1 Initial assessment questions with indicative values

The following questions are intended to prompt consideration of the revenue and cost categories which may influence a decision to engage in restoration, and to guide construction of a formal (spreadsheet) model to aid such decision making. Indicative values to use are suggested purely to facilitate worked examples and are subject to revision.

The questions apply equally to individual land managers and to the developers of restoration projects encompassing multiple land managers, with the caveat that perspectives may differ. That is, land managers need to receive sufficient funding to entice them to participate in restoration activities, but project developers also need sufficient funding and this may (but not necessarily) lead to retention of some revenue at the project level. In particular, developers may retain a proportion of PES funding (see Q11), with payments to land managers treated as a cost at the project-level but revenue at the site-level.

Revenue

What public funding via grant schemes is available?

What capital expenditure is eligible? e.g. fencing, dams, re-vegetation
- If % funding, to what level? e.g. 50%, 75%, 100%
- If standard costs, what unit values? e.g. per dam, per m of grip

What private funding via PES schemes is available?

What is the estimated carbon saving per ha?

What is the expected market price of carbon?
- Any additional payments for co-benefits?
- Any buffering required? i.e. what % reduction applied to area paid on?

Are there any additional revenue sources?
- Are any land uses compatible with restoration? e.g. extensive grazing, ecotourism
- Is such additional revenue subtracted from income forgone calculations?
- When taken together do government funding and additional revenue sources other than PES payments make up more than 85% of all the costs of the project?

Administrative and Compliance costs

Is a site survey required?
- If by professionals, multiply area by c.£16/ha.

Is a management plan required?
- If by professionals, budget for c.£800 (more for larger or more complex sites).

Do non-cash transaction costs (i.e. time spent) matter?
- If yes, add 5% to 15% to total of all other costs.

Will the project be validated to an independent PES quality assurance standard?
- If yes add [£700] – [£5,000] per project

- If the project will be validated to an independent PES standard as part of a wider group of projects add [£3,000] per project instead of [£5,000].

Opportunity costs

Is current land use profitable?

- What market revenue does it generate and how will this change? e.g. volume & quality of output?[117]
- What subsidy does it receive and how will this change? e.g. eligibility for SFP

What costs does it incur? i.e. what savings will be made by reducing this activity?

- Indicative values of £0 to £80/ha/year for upland grazing
- Indicative values of £0 to £100/ha/year for grouse management
- Indicative values of £0 to £370/ha/year for forestry

Is current land use compatible with restoration?

- If not at all, then assume complete displacement
- If partially (e.g. lower intensity and/or switched to other part of holding), what %?

Multiply current profit figure by displacement %.

Does the landowner desire or expect recompense beyond cost and opportunity cost recovery (i.e. do they wish to share in any profits that would be generated by the PES market)? If so what is their expectation per hectare per annum?

Capital costs

Does site require fencing for stock exclusion?

- If yes, multiply perimeter by £4.50/m to £10/m;

Does site include smaller grips?

- If yes, multiply by £7.50 per peat dam only, equivalent to £1/m for 7.5m spacing;
- Or by £1.55/m to £2.5/m if profiling also required.

Does site include gullies/larger grips?

- If dammed, multiply by £19 - £38 per heather dam, equivalent to £2.5 - £5/m for 7.5m spacing;
- If dammed, multiply by £150 - £300 per oak dam, equivalent to £20 - £40/m for 7.5m spacing;
- If reprofiled, multiply by £2.5/m;
- If re-vegetated, multiply area by c.£3500/ha to £5900/ha (for brash & lime) by ground or helicopter respectively;

Does the site include areas of bare peat?

- If yes, multiply bare peat area by £250/ha for reseeding or £4000/ha for planting;
- If fertiliser & lime required, multiply by £1700/ha for ground delivery or £1400/ha for helicopter delivery;

[117] This applies to all land use in terms of (e.g.) stocking densities, grouse bags, timber yields – with the latter also affected by how premature harvesting is.

- If brashing required, multiply by £1500/ha for on-site cutting or £1700/ha for ground delivery or £4500 for helicopter delivery;
- If geotextiles required, multiply by £9000/ha to £12000/ha;

Is removal of forestry cover required?
- If yes, but at planned harvest, no additional cost;
- If harvested prematurely, multiply by £5000/ha.

On-going costs

Will on-going management be required?
- If yes, multiply area by £5 or £10/ha/year.

Will on-going monitoring be required?
- If yes, multiply area by [£4] or [£10/ha/year].

Will the project maintain certification to an independent PES quality assurance standard?
a. If yes, multiply area by £5/ha for each year of PES contract period
b. Will the project maintain ongoing certification as part of a group of projects sharing monitoring and risk? If yes multiply area by £3/ha for each year of PES contract, instead of £5.

Discounting

Is discounting back to Present Values required?
- If yes, apply discount factor to future costs and revenues. e.g. current interest rate

Section 3: Quantifying the potential biodiversity benefits of peatland restoration projects under the Peatland Code

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3.1 Summary

It is widely recognised that biodiversity is a driver for peatland restoration. Biodiversity is also an important and widely appreciated message to use to engage with the general public and potential investors. Biodiversity can be used as a way of promoting projects, making projects with lower emission savings potential, such as restoring *Modified* to *Near Natural* condition bogs, more appealing if they can demonstrate greater biodiversity potential.

Currently it is not possible to put a monetary value on peatland biodiversity, with no single species or species group sufficiently indicating biodiversity quality consistently across the UK. However, if biodiversity is approached from a species-centred or numbers perspective there is a danger of getting little insight into ecosystem function, which is all about connections, networks and inter-relations. The presence/absence and abundance of keystone species does not necessarily indicate the presence/absence of a critical ecological function.

In light of the review of available data and approaches to biodiversity metrics, as well as considering the responses to questionnaires and information from peatland managers collated for this project, habitat condition has been identified as one of the key proxy measures of peatland biodiversity. Habitat connectedness and species groups are also key features for assessing potential benefits for biodiversity as a result of restoration.

To formalise this, a straightforward “star” rating system was developed. This method uses habitat quality, habitat networks and species groups as the markers for assessing the potential a project will have for enhancing biodiversity. Evidence for a project to improve each of these features can be gathered concurrently with the Field Protocol for assessing peatland condition and greenhouse gas emissions.

3.2 Objectives

The primary objectives of this Work Packager were to:

- Identify existing relevant metrics and indicators for quantifying biodiversity including the metrics developed by Natural England for biodiversity offsetting (which were subject to consultation in 2012).
- Assess how one, or a combination of these metrics might be developed or adapted for the specific needs of the Peatland Code, drawing upon relevant market research to ensure that the proposed metric could address the potential motivations of business for investing in peatlands.
- Consult with an appropriate number of restoration site managers to establish extent of available biodiversity data including: baseline data, biological monitoring currently being undertaken on peatlands, key species and data gaps.
- Review UK peatland biodiversity: assesses factors pertinent to selecting key indicators and considers the relative suitability of different species groups for contribution towards such a metric.
- Recommend immediate improvements to the Code in terms of a proposed metric, noting strengths and weaknesses in comparison with the carbon metrics.

3.3 Background

Paying for ecosystems restoration can be expensive, so it is often necessary to prioritise sites for restoration. The Peatland Code originally focused on calculating the quantity of carbon that might be safeguarded by restoration of any particular peatland. However, much peatland restoration is carried out in order to enhance landscapes, water quality, water flows, and biodiversity. This section of the report looks at ways to compare and contrast the biodiversity on different peatlands.

3.4 Review of UK Peatland Biodiversity

3.4.1 Background

3.4.1.1 Review Outline

The purpose of this section of the report is to provide an assessment of the potential to develop a biodiversity metric for peatland restoration. It considers the justifications for basing a metric upon peatland biodiversity, assesses factors pertinent to selecting key indicators and considers the relative suitability of different species groups for contribution towards such a metric.

The assessment is focussed primarily on blanket bog restoration, as it is the predominant bog type in the UK. Evidence presented is drawn from blanket bog examples but where the term peatland is used, it refers more broadly to mire, which include blanket bog and lowland raised bog habitats. References and examples are primarily based on information from Britain and Ireland though some other studies are cited where their findings are likely to have relevance also in the UK.

3.4.1.2 Importance of Peatland Biodiversity

Peatlands comprise the largest remaining semi-natural habitat in the UK and cover around 9.5% of the land area (Bain *et al.,* 2011). The UK has between 8.8 and 14.8% of Europe's peatland area

(Montanarella *et al.,* 2006) and about 13% of the world resource of blanket bog (Lindsay *et al.,* 1988).

The extent of peatland habitats has declined and much of the remaining resource is directly modified or is subject to deleterious influences. Only around 400,000 ha (18%) of the blanket bog resource in the British Isles is in a natural or near-natural condition whilst 16% is eroded, 16% is afforested, 11% is affected by peat cutting and 40% is otherwise modified such as by management for sheep or deer (Tallis, 1998) (for further information see JNCC (2011)). Even on the Natura 2000 designated sites, which typically represent the best examples of the habitat, fewer than half of all the assessments returned a result of favourable condition (Williams *et al.,* 2006). Information on non-designated sites is harder to obtain but in the North York Moors National Park, 79% of blanket bog on non SSSI-designated land has been deemed as requiring some form of restoration or enhancement (Littlewood *et al.,* 2010).

Peatlands host a range of specialised plant and animal species that are adapted to waterlogged, acidic and nutrient-poor conditions. These species are sensitive to changes in land management and a range of other external drivers. A high proportion of peatland species are rare or threatened and declines have been noted in populations and distributions of typical peatland species across a range of taxa including birds (e.g. Whitfield, 1997) and invertebrates (e.g. Brooks *et al.,* 2012). Peatland habitats are, therefore, recognised as being a conservation priority under UK and EU law with many sites classified under the EU Habitats and Species Directive. The bird assemblage, in particular, is highly valued in a European context, leading to protection of large areas as Special Protection Areas. Some plant assemblages are better represented in the UK than anywhere else in the world with the best areas being designated as Special Areas of Conservation.

3.4.1.3 Assessing Peatland Restoration

Habitat restoration is frequently planned around the assumption that creating habitat will lead to reassembly of target assemblages – or the “if you build it, they will come” premise. However this is rarely tested (e.g. Palmer *et al.,* 1997). Furthermore, there is considerable debate about the best way to set targets for restoration projects. Usually this is done by comparison of assemblages (most usually plant assemblages) with “reference sites” that are considered characteristic of habitat in good condition. A range of multivariate techniques can then quantify similarities or differences between samples from the restoration and reference sites (e.g. Poulin *et al.,* 2013). However it is difficult to precisely match sites and there is a risk of aiming to restore to an assemblage that would not occur naturally on a site. In peatlands in particular, palaeoecological techniques may provide an alternative insight into the vegetation that was typical on a site before the advent of negative drivers (e.g. Blundell & Holden, 2015)
Restoration may, alternatively, be focussed on reinstating a smaller suite of key species that are considered to be particularly characteristic of a site in good condition whilst minimising the abundance of species that are considered atypical or inconsistent with such a site (e.g. see González *et al.,* (2013) for a peatland restoration example).

However what might be considered a reasonable target or reference site in one part of the country may well not be considered realistic or indeed characteristic or natural in another part of the country. This is furthermore compounded by anthropogenic influences beyond the scope of what can be addressed by local site management, such as the relative paucity of Sphagnum mosses in Peak District sites that have been subject to atmospheric pollution (such as nitrogen deposition from industrial areas to the west e.g. Caporn *et al.,* 2006). Selecting appropriate local reference sites is desirable where this is possible. However, this still constrains assessment of restoration success to a single end point that may or may not contain the features that are necessary for the full restoration of ecosystem function that is usually considered important in the context of peatland restoration (see, Quin *et al.,* (2014) for an example of use of local reference sites in a multi-site assessment of the carbon benefit from heather moorland restoration).

3.4.2 Towards a Biodiversity Metric for Peatland Restoration

3.4.2.1 Plant or Animal?

Common Standards Monitoring (CSM) for site condition of blanket bog focusses exclusively on vascular plants, bryophytes and lichens (Anon, 2006). Peatland is defined according to environmental conditions and the plant species that maintain the ongoing accumulation of saturated and poorly decomposed material. As the building blocks of a habitat, and often the most direct indicators of environmental conditions, the vegetation species present and their spatial arrangement with respect to topography, are particularly instructive in terms of assessing peatland condition and function. Plant species are also good indicators of the biodiversity potential of a site and there are often strong links between the plant species and the fauna that is present. For example, Stephen *et al.,* (2011) show Dunlin numbers in the Flow Country have been shown to be strongly correlated with Sphagnum cover (Stephen *et al.,* 2011) whilst the structure of Sphagnum cover, and especially the presence of ephemeral pools in Sphagnum hollows, increases the range of peatland invertebrates present on a site (Hannigan & Kelly-Quin, 2012). Thus, in the absence of detailed faunal monitoring, plant assemblages reinstated following restoration may indicate the suitability of a site for hosting typical peatland species should these species be able to colonise/recolonise the site.

Furthermore, methods for monitoring peatland vegetation assemblages are well established and, given the importance of a relatively small number of species in peat formation, a suitable indictor may be straightforward to develop. and, indeed, such an indicator may differ little in terms of vegetation targets from the CSM definitions.

On the other hand, many peatland sites are widely recognised for other elements of biodiversity that contribute substantially to the overall value of the site. A range of birds, mammals, amphibians, reptiles and invertebrates are cited as designated features in SSSI notification whilst Special Protection Area designations extending over large parts of the UK's blanket bog resource, further recognise the importance of bird assemblages in an EU context. Some invertebrates play a crucial role in nutrient cycling in peatlands (e.g. Coulson & Butterfield, 1978) whilst management for birds and mammals may be a large element of the economic value of peatlands in some parts of the country, both for sporting purposes and for generating tourism income. Biodiversity indictors in addition to vegetation metrics may, therefore, play a valuable role in recognising and assessing these wider benefits of biodiversity. When taken also with the fact that vegetation characteristics will be used as a proxy for carbon sequestration within restoration schemes by the Peatland Code, the development of biodiversity metrics based on faunal characteristics would add a further element and assist in recognising the value of, and encouraging management for, peatland biodiversity as a whole.

3.4.2.2 Species Richness in Peatland

In developing a biodiversity metric for peatland restoration, the relatively low species diversity of at least some taxa in these areas needs to be recognised. Species richness itself is generally an unhelpful metric in assessing peatland condition and a higher value for species richness may, in some cases, actually indicate habitat disturbance or degradation. For example, beetle species richness has been found to be higher in conifer plantations than in adjacent blanket bog (Gilbert *et al.,* 2014). Diversity of some taxa, especially plants, may be relatively high on a very small scale (alpha diversity) in blanket bog. In such cases, low nutrient conditions leads to coexistence of a range of specialised species and those species that in degraded conditions may form dominant tussocks, such as Deergrass (*Trichophorum cespitosum*) and Heath Rush (*Juncus squarrosus*), tend to grow through the moss layer as isolated stems. Fine scale topological variation, in the form of different microhabitat niches formed by pools, hollows, ridges and hummocks, can lead to moderate Beta diversity but with this pattern being replicated extensively across a landscape (when in good condition) Gamma diversity (reflecting overall species richness of a site) can be relatively low. This is most clearly illustrated by species richness of larger taxa such as birds and mammals for which only a relatively small number of species thrive in blanket bog conditions.

For some groups, though, peatlands may actually host a rather large range of species. Invertebrate groups that are more dependent on vegetation structure than plant species composition can be especially diverse. This includes groups such as spiders (Scott *et al.,* 2006), especially money spiders (Lyniiphidae) (Coulson & Butterfield 1986) and ground beetles (e.g. Usher 1992). Nonetheless, very few studies have been published looking at the response of arthropods, especially terrestrial arthropods, of UK blanket bogs to restoration. A wider range of studies has been published regarding upland heathland restoration and management and, for some taxa at least, there is considerable overlap between the species of these habitats such that findings and methodologies used in upland heathland may have relevance in blanket bog.

3.4.2.3 Selecting Suitable Taxa

Bonnett *et al.,* (2009) reviewed a number of techniques for assessing biodiversity in peatland restoration schemes. However, their work focussed more closely on assessing the suitability of applying different monitoring methods to peatlands rather than assessing which taxa were most suitable as indicators of peatland restoration success. Here, whilst sampling methods will be briefly assessed, precise details of sampling programs are not proposed. These would need to be developed, trialled and assessed for suitability in providing robust metrics and practicality in their execution in field situations.

As discussed above, straightforward diversity indices are unlikely to be useful in assessing the success of peatland restoration with habitat modification in blanket bog having the potential to increase the diversity of at least some species groups. Metrics can therefore be based either on indicator species or on community composition.

Simple metrics based on presence of conspicuous and easily-sampled species may be tricky to develop. An increase in, for example, the number of breeding pairs of Merlin (*Falco columbarius*) may be celebrated as a positive outcome of habitat restoration. The relatively low numbers overall, though, of such key species means that the likelihood of meeting a target based on such a metric would be more likely to be influenced by stochastic events than would be the case for more numerically numerous and species-rich taxa for which responses to management can be measured on a more graduated scale.

The most suitable metrics for use as indicators, therefore, may be assemblages of those groups of species that respond most directly to features of the vegetation that are characteristic of natural peatlands. Some potential taxa are considered below.

3.4.3 Assessment of Key Species Groups

3.4.3.1 Breeding Birds

Importance: Birds are among the more conspicuous biodiversity of peatlands and are a significant driver behind the designated status of large areas of blanket bog. The assemblage of the Flow Country, in particular, is recognised as being a northern fauna found nowhere else globally in identical composition (Stroud, *et al.,* 1987). Whilst even more southern sites can hold important populations of species that are localised in their UK breeding distribution (Stillman, 1994). Eleven of the 29 UK priority species associated with blanket bog are birds whilst some thirty bird species that are associated with peatlands have elevated conservation status over and above the basic protection afforded to all wild birds (Littlewood *et al.,* 2010).

Sampling: A wide range of methods can be employed for sampling breeding birds. These include methods for sampling all species present on a site through to single species monitoring methods. In upland areas, Moorland Bird Survey (Brown & Shepherd, 1993) has been routinely adopted and involves standardised time spent per unit of area.

Whilst surveying for birds requires a good level of skill in field identification by sight and sound, there is a relatively large number of fieldworkers who possess these necessary skills. Furthermore, given the smaller suite of species present and the open terrain of peatlands (so it is easier to see as well as hear birds), there may be a larger resource of fieldworkers with sufficient skill level than is the case for lowland areas and woodlands.

Pros: Some bird species are characteristic of peatland areas and show sensitivity to declines in peatland condition. For example, Dunlins are most strongly correlated with ground wetness and the cover of Sphagnum mosses (Avery & Haines-Young, 1990, Stephen *et al.,* 2011).

Birds are often among the most valued of peatland biodiversity as they are more likely to be seen and identified by land managers and visitors. They are also the most valued element of peatland biodiversity in terms of legislative protection. Achieving metrics based on birds may therefore prove to be popular in a societal sense by providing “flagship species” with which to demonstrate successes from restoration management.

Cons: Most birds breeding on blanket bog are not resident in the habitat year round. Some species will move to lower ground in the UK or NW Europe in winter whilst others are long-range migrants. As such, they are subject to a wider range of influences on their populations than are largely sedentary taxa. Many of the species of blanket bog are towards the southern parts of their ranges in the UK, and may thus be particularly vulnerable to the effects of climate change (e.g. Hampe & Petit, 2005). For example, the breeding distribution of Golden Plover has declined at the 10 km square resolution by 20% in Britain over the past 40 years with most declines being towards the south of the range (Balmer *et al.,* 2013) with climate-driven reductions in prey availability being demonstrated to be a key driver in this (Pearce-Higgins *et al.,* 2010). Thus peatland restoration alone may be insufficient to rehabilitate populations. Given that extensive monitoring is carried out of UK breeding birds, and that periodic publications of data on national trends are available (e.g. Baille *et al.,* 2014), calibration of appropriate targets may be possible.

A connected potential problem is that the distribution of peatland birds within the UK is patchy and key species may occur at relatively low densities or in localised environments. Among the more numerous and widely distributed breeding species in the Flow Country are Golden Plover (*Pluvialis apricaria*), Dunlin (*Calidris alpina*) and Greenshank (*Tringa nebularia*). Of these, Greenshank breeds primarily north of the Great Glen and none breeds south of the Highlands whilst Golden Plover and Dunlin are both fairly widespread on blanket bog north of Central Scotland and also in the Pennines but are otherwise increasingly patchily distributed towards the south of the range (Balmer *et al.,* 2013). More widespread peatland breeding birds include species such as Meadow Pipit (*Anthus pratensis*), Curlew (*Numenius arquata*), Lapwing (*Vanellus vanellus*) and a selection of raptors. These species, though, all have a weaker affinity with peatlands.

Peatland restoration may improve the status of some species (especially restoration from commercial forestry) though some species may be more common on degraded open sites than undamaged bog with, for example, Lapwing favouring areas that have been drained of managed to increase pasture (Stroud *et al.,* 1987). A selection of waterfowl species breed on peatlands but again is patchily distributed and generally linked to the presence of lakes or lochs and so may be unsuitable for a widely used metric. Some breeding birds of blanket bogs are influenced also by off-site factors, even during the breeding season – e.g. Golden Plovers often show a preference for feeding on improved land well away from blanket bog nest sites (e.g. Ratcliffe, 1976). Such factors in blanket bog breeding bird distributions may significantly hamper the establishment of robust and locally-relevant targets that directly reflect the success of restoration management.

An additional factor in introducing a metric based on birds is that it may incentivise management of those species selected which does not, in itself, promote improvement of peatland habitat condition. Notable among peatland breeding birds are a range of wader species. Predator control has been shown to have a positive impact on nesting success of Curlews in upland areas and may serve to maintain otherwise vulnerable populations where nearby woodlands remain (Douglas *et al.,* 2014).

3.4.3.2 Aquatic Invertebrates

This category is used here to cover a range of taxa that have at least an aquatic larval stage and, in some cases, are completely aquatic. These species include dragonflies and damselflies, aquatic Coleoptera, aquatic Heteroptera and a range of Diptera species. They are considered together as they can be caught together in samples and are frequently treated as a single functional group in monitoring and research.

Importance: Bog pools can add considerably to the species richness of a peatland site and are a significant part of the biodiversity importance. Their fauna is also sensitive to fine scale habitat variation making them potentially very instructive as indicators of habitat quality. Aquatic invertebrates provide food for a range of specialised peatland species, such as Common Scoters (*Melanitta nigra*).

Sampling: Sweeping with a pond net within the water is the most frequently used method. The duration and area sampled should be standardised between sample sites to enable quantitative comparisons. Examples of such approaches can be found in, for example, Hannigan & Kelly-Quinn (2012). A number of other sampling methods are used at times for aquatic invertebrates in bog pools such as baited activity traps (e.g. Drinan *et al.,* 2013) and plastic funnel minnow traps (e.g. Mazerolle *et al.,* 2006).
Aquatic invertebrate taxa differ widely in the degrees of difficulty in their identification. Many adult aquatic Coleoptera and Heteroptera and larvae of Odonata can be reasonably straightforward to identify whereas Diptera larvae require a much higher skill level.

Pros: This group as a whole can be rather species-rich and show good sensitivity to water and pool type and to environmental conditions that impact on water quality. Thus sampling in bog pools can be rather instructive of peatland conditions. Bog pools may contain rare or specialised species whilst differences in assemblages may be driven by correlates of habitat condition such as pH (Baars *et al.,* 2014). Species composition may be affected by how life traits interact with habitat. For example, Sphagnum hollows that sometimes dry out can host species where juvenile development can be delayed (Hannigan & Kelly-Quinn, 2012). Surrounding land use may also affect the species assemblage of bog pools (Drinan *et al.,* 2013).

Cons: Bog pools only ever make up a small proportion of blanket bog area and, whilst aquatic invertebrate assemblages in them may reflect the conditions of surrounding habitat, this will be biased toward the immediate surroundings.

Whilst a degree of topographic variation is characteristic of bogs in good condition, sites will vary considerably in the range of naturally occurring pools that they hold. Pools may be created within peatland restoration schemes, such as through ditch blocking. However, apart from on sites where degradation was marginal and where significant features of natural topography remain (possibly including sites where the main drivers of degradation have been burning or overgrazing), it is unlikely that the fine mosaic of small seasonal natural pools could be recreated, at least in the early years of restoration. Comparisons could be made between faunas of the more permanent pools on restored ground and permanent natural pools, especially as these may respond to altered hydrological states driven by restoration management, but this would restrict the metric to considering just a sub-set of pool types, and hence potential species, involved.

3.4.3.3 Odonata (Dragonflies and Damselflies) Adults

Importance: Two thirds of Britain and Ireland's Odonata (dragonfly and damselfly) species, use peatlands and 11 of these are almost restricted to peatlands (Brooks, 1997). The majority of these are more closely linked with lowland bogs and fens than with blanket bog sites. A number of species, though, are characteristic of blanket bog, such as the Azure Hawker (*Aeshna caerulea*), which shows a particular link to this habitat (Cham *et al.,* 2014).

Sampling: Systematic monitoring protocols are not as well developed for Odonata as they are for some other groups. The British Dragonfly Society has been developing the Dragonfly Monitoring Scheme which uses counts along a repeatedly walked transect (Smallshire & Benyon, 2010). This, though, involves routes alongside water margins and, in the intricate mosaics of bog pools, the method may be less applicable.
Adult Odonata are generally easy to identify given good views and a basic level of skill and it is usually possible to confidently identify to species level from good photographs if an unfamiliar species is encountered. There are good distribution data for this popular range of insects, recently published by Cham *et al.,* (2014).

Pros: Odonata are recognised as good indictors of water quality and often show preferences for a specific pH status for breeding sites.

Cons: The range of species present in the UK is small, especially in more northern areas. Most species of bog environments are not restricted to the habitat and, in some cases, might indicate the proximity of marginal bog environments. For example, the Northern Emerald (*Somatochlora arctica*) breeds in Sphagnum areas with little open water but is generally found where there is some ground water influence (e.g. Cham *et al.,* 2014).
The activity patterns of Dragonflies and Damselflies are very restricted by weather conditions. Few will be found flying in dull conditions whilst strong wind will also impair activity. Some specific structural features, in particular those providing shelter such as trees or embankments, may attract the larger species such as Hawkers and Emeralds. Thus more dragonfly activity might be recorded on areas at the edge of bogs even for species that breed out on the bog well away from the edges. This may skew attempts to assess how the Odonata richness of a site is linked to restoration management.

3.4.3.4 Spiders

Importance: Spiders can be a species-rich group on bogs. Scott *et al.,* (2006) recorded close to half the UK species from lowland raised bogs. Peatlands host a number of rare or specialised species. For example, spiders comprise four of the 41 UK Priority species associated with peatland (Littlewood *et al.,* 2010) and 11 of 77 notable invertebrate species associated with blanket bog and six of these 11 are restricted to the habitat (Anon, 2010).

Sampling: Scott *et al.,* (2006) sampled primarily using pitfall traps but supplemented this with litter sieving and hand collection from emergent vegetation. Oxbrough *et al.,* (2010) demonstrated that using Malaise traps in peatlands can usefully complement pitfall trapping. With a similar number of individuals in their pitfall and Malaise trap samples, they recorded slightly more species in pitfall traps but with some additional species recorded by Malaise traps that were not recorded in pitfall traps. If Malaise trapping is being carried out for other taxa, it would be worth considering using the samples also to provide a metric of the reassembly of spider communities on restored sites.

Spider identification, especially of the Linyphiidae which form the largest family proportion in peatland samples (e.g. Oxbrough *et al.,* 2010), requires a relatively high skill level and there are fewer personnel capable of making reliable identifications than is the case for some of the more conspicuous invertebrate groups.

Pros: Spider assemblages of peatlands have been shown to be more sensitive to change than in other open habitats with specialised assemblages being lost with peatland modification (Oxbrough *et al.,* 2006). Scott *et al.,* (2006) used spiders to assess the conservation value of lowland bogs in Cheshire in a study which could help significantly to inform pilot studies using a range of other taxa. They assessed the suitability and efficiency of sampling protocols to enable comparison between sites and developed a naturalness index based on species deemed characteristic of the habitat. This, they considered, was a better metric for describing the conservation value of a site than straightforward diversity indices, though it does require agreement on which species are considered appropriate to include.

Cons: The primary drawback of using spider assemblages as a peatland restoration metric is the time required and relative difficulty in identification, especially of the smaller species that predominate in peatland samples.

3.4.3.5 Carabids (Ground Beetles)

Importance: Ground beetles can be relatively species rich in blanket bog and other related heathland habitats (e.g. Usher, 1992) and two species are included among the 77 notable invertebrate species listed as being associated with blanket bog (Anon, 2010).

Sampling: Ground beetles are most commonly sampled by use of pitfall traps. The Environmental Change Network (ECN) Ground Predator protocol (Skyes & Lane, 1996) involves the establishment of transects of ten pitfall traps, 5 m apart, which are emptied fortnightly from spring to early autumn. Like any other method, pitfall trapping is has its biases. In particular pitfall traps catch more of the larger, more active species (e.g. Hancock & Legg, 2012) which limits the potential for direct comparisons of relative abundance between species. However there are several advantages of this method (e.g. cost, replicability, non-dependence on good weather, etc.) and the number of adult ground beetles caught in blanket bog can be significantly more than with alternative sampling methods (e.g. Coulson & Butterfleld, 1985).

Fieldwork is not especially labour intensive and it is possible to collect a good number of specimens with just periodic visits to empty and re-set pitfall traps. Pitfall trapping typically involves taking dead specimens which are later examined in the laboratory. Many carabid species are fairly straightforward to identify with a little training and standard keys are available, though accurate identification of some of the species does involve a higher level of specialised skills.

Pros: Ground beetles are largely carnivorous and, as such, respond more to vegetation structure than composition. They are sensitive to soil conditions with McDonnell *et al.,* (2002) reporting a significant positive relationship between soil moisture levels and carabid species richness. They have also been shown to be sensitive to a number of other factors linked to peatland condition such as nutrient status and livestock grazing (e.g. Holmes, 1993). Thus assemblages may be good indicators of variation in ground conditions in peatlands.

There are good precedents for investigating associations between ground beetles and habitat variation in peatland environments. They have also been sampled from peatland sites since 1992 as part of the UK ECN. Of the 12 terrestrial ECN sites in the UK, ground beetles have been sampled in blanket bog at three (in the Pennines, Scottish Borders and Aberdeenshire).

Cons: Declines in populations have been noted over the last 20 years at the peatland sites (Brooks *et al.,* 2012) and some indications are that species most in decline are those unable to alter their phenology in response to changing climate-related conditions (Pozsgai & Littlewood, 2014). Such temporal changes in assemblages are unlikely to be limited to ground beetles, though, and the availability of data from this long-term monitoring program at sites under stable management may act to provide a form of ongoing calibration to community indicator values for a peatland biodiversity metric.

3.4.3.6 Moths

Importance: Species-richness on bogs is lower than in many other habitats, likely reflecting the relatively narrow range of plant species present and their low nutritional status. However a range of species does feed on typical vascular plants of bogs (less so on bryophytes) and a number of species are characteristic of such habitats. Indeed, preliminary work at Forsinard shows a distinct moth assemblage, including several localised species, of bogs compared to surrounding areas undergoing restoration and radically different to those found in remaining conifer plantations (Nick Littlewood, unpublished data).

Sampling: For moths, a number of sample strategies could be employed. Most frequently, adult moths are caught as these are, on the whole, easier to identify than immature stages. Light-trapping is the most frequent method and a number of trap types are available. Traps with low-wattage actinic bulbs run from lead acid batteries or lightweight lithium batteries ion may be most suitable in remote locations. Solar panel chargers can be used to reduce the need to transport batteries.

Moth trapping usually involves the live capture, recording and release of moths (though specimens can be retained of harder to identify species or, if required, traps can be used which kill moths for later identification). Many adult moths, especially macro moths, are straightforward to identify in the field and can be processed and released quickly by an experienced fieldworker. A greater skill level is required, though, for some species and dissection of specimens is often required for reliable identification. Micro moths are less well-represented in light traps though members of the family Pyraloidea can be abundant and are generally straightforward to identify with practice.

Pros: Lepidoptera are relatively species rich in the UK (>2500 species) and have phytophagous larvae so are sensitive to vegetation composition. Moths are a relatively known group, especially to 1000+ species of “macro moth”. Feeding preferences, life histories and habitat associations are, on the whole, well-documented. Furthermore, distribution information is far better known and well managed for the macro moths than for most or all other invertebrate groups (e.g. Hill *et al.,* 2010). This may enable construction of regionalised subsets of target species.

Cons: The principal bias in light-trapping is that different species are differently attracted to light and some diurnal species are very unlikely to be caught. Additionally, in any sampling of adult moths as indicators of peatland condition, the mobility of these insects needs to be recognised as light trapping will likely attract species from beyond the immediate vicinity. This reduces the value of using simple site inventories for assessments but multivariate analyses should be able to give indications of similarities to reference sites (see Littlewood *et al.,* (2006) for an example from heather moorland).

Whilst moth sampling may require less subsequent lab work to identify specimens, fieldwork can be time consuming. Large day to day variability in catches between nights, linked to weather conditions, means that robust comparisons between restoration areas and reference sites should ideally involve simultaneous sampling. If live-trapping is to be carried out, this involves early-morning fieldwork to process the catch as moths will gradually become active and escape the trap as it warms in the sun.

Table 3.1 Summary of key groups considered in text and subjective assessment of features relevant to their use as part of a biodiversity metric for blanket bog restoration

Key Species Group	Species richness	Ease of Sampling	Ease of Identification	Species ecology knowledge
Birds	Low	Medium	High	High
Aquatic Invertebrates	Medium	High	Low/Medium	Low
Odonata	Low	Medium	High	High
Ground Beetles	Medium	High	Medium	High
Spiders	High	High	Low	Medium
Moths	Medium	Medium	Medium/High	High

3.4.3.7 Some Additional Groups of Peatland Fauna

Some groups of species, whilst containing species that are characteristic component of peatland biodiversity, are unlikely to be suitable for contributing towards a biodiversity metric. This may be due to the low number of species within the group, identification difficulties or that fact that the peatland species are found across a range of habitats and are not known to be especially sensitive to peatland conditions. For other groups, lack of comprehensive national distribution datasets would make it hard to identify which species are more relevant for restoration sites in different geographic areas. Some of these groups are discussed briefly below but not further considered.

Mammals on peatlands are represented by a range of generalist species and species that are restricted either to wet environments, such as Otter (*Lutra lutra*) and Water Vole (*Arvicola amphibious*), or to upland areas, in particular Mountain Hare (*Lepus timidus*). Small mammals tend to be scarce on blanket bog with the exception of shrews, and Pygmy Shrew (*Sorex minutus*) may occur in a higher ratio to Common Shrew (*Sorex araneus*) than in other environments (e.g. Butterfield *et al.,* 1981). Nonetheless, all these species can occur commonly in areas surrounding blanket bog and elsewhere and are not good indictors of bog restoration.
Peatlands can hold significant populations of reptiles, particularly Common Lizards (*Zootoca vivipara*) and Adders (*Vipera berus*). However these species are also commonly found on dryer heather moor and grassland habitats and are also not considered good indicators of bog condition.

Amphibians may occur where there is open water but are rarely common in peatland areas and most species do not thrive in highly acidic waters (e.g. Pakkasmaa, 2003) though Palmate Newt (*Lissotriton helveticus*) is more tolerant of acidic conditions than other newt species (Baker *et al.,* 2011). For similar reasons, fish communities in bog environments tends to be species poor.
A wide range of invertebrate groups are not considered here in detail. Few butterfly species are found on blanket bog, especially on exposed northern sites. One species that is characteristic of these areas is the Large Heath (*Coenonympha tullia*) and this species suffers as a result of habitat degradation in peatlands (Weking *et al.,* 2013). Populations of Large Heath, monitored through standard transect methods (e.g. Pollard, 1977), could be considered as a metric at some sites. However there is evidence that the species may suffer increased larval mortality as a result of raised water levels in peatland restoration schemes (Joy & Pullin, 1997) and so population indices may fall

during early restoration stages. Additionally, weather-related annual fluctuations in populations would mean that monitoring would need to be carried out over a long time period to reveal how the species has responded to management.

There are a wide range of beetle families in addition to ground beetles covered above with some 4000 species (of which the ground beetles make up 350). Many families differ very considerably in their ecology, feeding strategies and living habits and so the group does not lend itself as a whole to any one sampling method. Whilst, with appropriate expertise, several families could lend themselves to being used as indicators of habitat condition, the accumulated knowledge of and simple sampling technique for ground beetles makes them the most suited beetle group for initial consideration of a peatland biodiversity metric.

Hymenoptera and Diptera are the most species rich insect groups in the UK, each containing around 7000 species. Despite their presumably strong contribution to the species richness of peatlands, Identification and sampling challenges make the development of a generally-acceptable metric for Hymenoptera an unlikely achievement. More entomologists are active in Diptera identification but considerable challenges still exist and many practitioners concentrate their efforts on a sub-set of sub-orders of families. Some Diptera are recognised as important prey items on blanket bogs (e.g. Pearce-Higgings *et al.,* 2010) and sampling of such groups could provide useful information for investigating food webs and nutrient pathways.

3.4.4. Problems/Limitations in Developing a Peatland Biodiversity Metric

3.4.4.1 Site Size and Isolation

Site size and isolation may limit to the potential to which species can be supported on a site. Small isolated bogs, even if restored to or maintained in a good condition, may not contain key peatland species that may be characteristic of larger sites. Species distribution research is increasingly revealing how some species exist across networks of sites in a metapopulation formation, such that following localised extinctions, recolonization is possible from other sites productive sites. Increased fragmentation of peatlands may reduce the potential for some species to re-colonise and so make the long term persistence of a species at a site increasingly vulnerable to stochastic events. Hence a species may be absent from a site that contains the best possible habitat for that species and which is within the broad distribution range of that species. For example, in conjunction with site quality, isolation has been shown to be important in determining the presence or absence of the Large Heath butterfly (a bog specialist) across a range of lowland raised bog sites in Northumberland (Dennis & Eales, 1997).

3.4.4.2 Site Location

Whatever the size of a peatland restoration area, surrounding landscape has the potential to affect at least some elements of peatland biodiversity. This is recognised in the Peatland Code by establishment of buffer zones of sympathetic management. Surrounding impacts may occur through altering hydrology, especially if management is not at the mesotope scale, and this may impact on specialised peatland fauna (e.g. Drinan *et al.,* 2013). Physical characteristics of surrounding landscapes may also impact beyond their immediate extent. For example standing forestry adjacent to blanket bog is associated with lower abundances of at least some key breeding birds in blanket bog areas (e.g. Avery, 1989; Hancock *et al.,* 2009) whilst anecdotal evidence suggests that foraging adults of some peatland dragonfly species may benefit from feeding in areas of increased temperature and reduced wind speed along forest edges. Such factors mean that a biodiversity metric may not directly respond to the pursuance of best practice in peatland restoration.

3.4.4.3 Data Quality

Data quality and availability vary across species groups. Table 3.2 gives a basic assessment of data availability for some key groups, based primarily on data from national recording schemes, which generally hold the most complete and most reliable datasets. For some groups, many more data will be available elsewhere based on site monitoring reports, locally-held datasets, etc. It should be noted that even for well recorded groups the distribution of species records is biased by the activity of recorders. For macro moths, for example, the single most under-recorded part of the UK is east Sutherland, coinciding precisely with the UK's most extensive blanket bog area and for many hectads in this region, there were no records at all included in the most recently published maps (Hill *et al.,* 2010).

Table 3.2 Assessment of data availability for some groups of species that might be considered for use within a biodiversity metric for peatland biodiversity. This table includes all species/records in each dataset, not just those of peatlands.

Species Group	Species in dataset	Number of records	Dataset Owner	Source
Breeding Birds	261	>19,000,000[1]	BTO (Bird Atlas 2007-11)	Balmer *et al.,* 2013
Odonata	56	999, 856	Dragonfly Recording Network	NBN upload 2014 (and Cham *et al.,* 2014)
Spiders	657	516,689	Spider Recording Scheme	NBN upload 2008
Ground beetles	352	130,737	Ground Beetle Recording Scheme	NBN upload 2001
Macro Moths	1,087	17,028,992	National Moth Recording Scheme	NBN upload 2015

1. Total includes wintering bird records

3.4.5 Conclusions and Key Messages

- Peatland biodiversity is widely valued due to its range of specialised and sometimes rare species.
- A biodiversity metric for peatland restoration has the potential to incentivise management of this resource.
- A biodiversity metric focussed on vegetation complements the objectives of peatland restoration under the Peatland Code and Common Standards Monitoring of designated sites.
- Specialised peatland faunal species are frequently sensitive to vegetation composition and structure and to ground conditions.
- The presence of abundant Sphagnum and related topographical heterogeneity may indicate suitability for a wider range of peatland species than where Sphagnum is scarce and the hummock/hollow micro-topography is less well defined.
- Metrics based on a wider range of biodiversity recognise valued site features and incentivise development of a whole suite of peatland species.
- Analysis of community composition for one or more species groups is likely to be more instructive that is adopting a small number of indicator species.
- Species groups should be selected for use in a biodiversity metric based on their species range within peatland, their sensitivity to peatland habitats, their ease of sampling and identification and the quality of knowledge of national distributions.
- Targets for a peatland restoration biodiversity metrics should be locally relevant, based on the pool of species present in the general area.

- Targets within a biodiversity metric should recognise site size and connectivity with potential source populations of peatland species.

3.5 Approaches to Wetland Biodiversity Metrics

Biodiversity is by its nature diverse and dynamic, and although it might be possible to show changes in biodiversity at a single site, it is difficult to objectively monitor, assess and compare the biodiversity of different sites. A 2012 report by the United States Environmental Protection Agency (Faber-Langendoen *et al.,* 2012) developed a complicated system based on ecological integrity. The work used existing spatial datasets and classification systems as the basis for sampling design, developing and assessing metrics for various aspects of wetland condition, and synthesized the results into an ecological integrity score, concluding that 16 different metrics would be required:

- Landscape context: connectivity, land-use, barriers to landward migration, buffer zone
- Size: relative patch size (ha), absolute patch size (ha)
- Vegetation Condition: vegetation structure, regeneration, native plant species cover, invasive/exotic plant species cover, vegetation composition
- Hydrological Condition: water source, hydroperiod, hydrological connectivity
- Soil Condition: physical soil types; soil surface condition

There is also evidence to support the positive correlation between wetland condition and other ecosystem services. Meli *et al.,* (2014) also tried to identify the key factors for a biodiversity metric for wetland restoration. They performed a meta-analysis of 70 experimental studies and used response ratios and random-effects categorical modelling in order to assess the effectiveness of ecological restoration. Restored wetlands showed 36% higher levels of provisioning, regulating and supporting ecosystem services than did degraded wetlands. Recovery of biodiversity and of ecosystem services were positively correlated, indicating a win-win restoration outcome; however the measurements focussed on the diversity of species (vertebrates, vascular plants, terrestrial and aquatic invertebrates, and macro-invertebrates) rather than on a more nuanced assessment of habitat condition.

The approach suggested by Treweek *et al.,* (2009) for the UK involved focus on habitat distinctiveness and habitat condition, dividing habitat condition into 3 categories according to whether management is optimal, sub-optimal, or seriously damaging. By 2010, Treweek *et al.,* had increased these to 4 condition scores: poor, moderate, good, optimum (although it is not clear if these were related to management or management outcomes).

Other schemes have also been devised and trialled, of which the best known is probably that used in Australia, and adapted for use in the UK for a trial biodiversity offsetting scheme. Table 3.3 gives examples of some of the main pros and cons of some of the most relevant approaches developed.

Table 3.3 Example approaches to biodiversity metrics and schemes for habitat restoration and their potential applications to peatlands in the UK

Scheme	Concept	Metric	Synergies with Peatlands
Habitat Hectares (Australia)	Measuring the condition of native vegetation against a benchmark within a bio region. Determines the losses from clearing native habitats and the gains at an offset site.	Site base assessment undertaken by qualified (and scheme certified) ecologists. Requires the definition and mapping of Ecological Vegetation Classes (EVC) [like NVC but more than plants - described using floristic lifeforms and ecological characteristics and inferred fidelity to particular environmental attributes]. Also identifies weeds and health of plants. Government has interactive EVC map of bio regions.	Rigorous way of quantifying all habitat quality. Regionally specific so would pick out climatic differences. Requires extensive mapping and benchmarking of native habitats. Needs qualified experts to carry out surveying, which would be expensive.
Biodiversity Offsetting Pilots (Defra, UK)	To expand and restore habitats, but not change existing levels of protection. Be managed at a local level. Contribute to ecological networks. Be simple, straightforward and transparent.	Uses HLS Condition Assessment protocol. Based on three habitat bands - High, Medium and Low. High is a priority habitat, medium is semi-natural, low is intensive agriculture. Want to see a shift up (no trading down). Local authorities can add their own conditions (eg. to recognise importance of habitat locally).	Is a multi-attributes metric. Uses habitat quality. Uses existing field protocol (widely reviewed and assessed by stakeholders). Only three categories. Metric not designed specifically for this purpose (agri-environment scheme). Not the same across the UK (as local authorities can put on their own conditions).
Scottish Borders Council Offsetting Scheme	Planning approach to biodiversity offsetting – in response to renewable energy development. Aims to mitigate impact of developments (if impact cannot be mitigated development may be refused planning permission).	Follows Environmental Impact Assessment Framework and identifies where impacts cannot be mitigated onsite and whether there is a compensation requirement. Uses legal agreements under Local Government Scotland Act 1973 or Section 75 of the Town & Country Planning Scotland) Act 1997. Offsets then secured by provider through regional partnership.	Landscape scale restoration, including blanket bogs, and suits multi-benefit projects (fed into biodiversity and catchment management plans). Some measures only relate to short term management (and can rely on additional leverage from agri-environment schemes (short term revenue).

3.6 Biological monitoring on peatlands: data availability and metric design

More than 50 peatlands (a conservative estimate) are being restored in the UK (Peat Compendium 2015). In order to provide some baseline data for this project, we asked a small sub-sample of the managers of these restoration projects to provide information about the biodiversity data they were gathering, and which data they felt was most useful as source, and applicable and important to them, for a biodiversity metric[118].

The extent of biological monitoring on peatlands varies considerably across the UK, between sites and projects (Table 3.4). Standard datasets, such as NVC classifications and site condition (within the Site Condition Monitoring framework) are mostly available on designated sites or where landowners such as NGOs and Forestry Commission have had a need for data to inform management. Far less is available on peatland sites where restoration is, or has been, undertaken. The most comprehensive account of the impact of restoration activities on biodiversity come from large EU funded projects such as the MoorLIFE[119] in the Peak District and South Pennines. In general, beyond these large projects, biological monitoring is on an ad hoc basis, when funding can be found, when staff have particular interests and expertise, or when students use sites for research projects. Increasingly, however, surveys are being carried out by volunteers through Citizen Science initiatives. This is particularly successful when key species groups are targeted such as bumblebees or where identification is relatively easy (e.g. butterflies).

A unanimous response from those questioned for this project is that funding for long term monitoring is the biggest single barrier to surveys being undertaken by peatland managers. Staff resources in most instances are not sufficient to have a standardised and rigorous approach to monitoring peatlands. This is particularly exaggerated on non-designated sites, which have not been required to meet Favourable Condition targets.

On-going work at the Humberhead Levels, a lowland cutover peatland, (Tim Graham and Ian Croshher, briefing note in prep, pers. comm. 2015) illustrates some innovative approaches to prioritising sites for restoration, focusing on using the clarity of the Lawton Report[120]: which recommends that the UK's wildlife sites need to be Better; Bigger; More and Joined. They also highlight the concept of a fully functioning ecosystem, and develop a restoration framework and monitoring metrics (score cards of zero to 100) that would be suitable for use in the restoration of cutover bogs, and which might be usefully developed for other peatlands.

[118] Information was gathered using a questionnaire in January and February 2015, and from presentations given at the MoorLife 2015 conference "An Integrated Approach to Upland Biodiversity", organised by Moors for the Future, Halifax, 3-5th March 2015 http://www.moorsforthefuture.org.uk/moorlife-final-conference
[119] http://www.moorsforthefuture.org.uk/moorlife [Accessed on: 19th March 2015]
[120] http://archive.defra.gov.uk/environment/biodiversity/documents/201009space-for-nature.pdf

Table 3.4 Examples of the monitoring being undertaken on peatlands across the UK

Project Area	Biological Monitoring and Available Data	Key characteristics identified for a potential biodiversity metric	Identified Data Gaps
Exmoor	• Quadrat and transect vegetation monitoring • NVC • communities and species	Ideally need a standard UK classification.	Use of vegetation as a proxy for water quality
North west Peak District	• Survey for individual species: eg. curlew, shorteared owl, dunlin, golden plover, skylark, red grouse, carrion crow, water vole, ring ouzel, bilberry bumblebee, green hairstreak butterfly, cranefly	Hydrology in August: damp August soil good for cranefly eggs, 2 years later the this results in abundant craneflies, which in turn feeds peatland birds. Sphagnum moss, which engineers the water table	• Long term data • Data from before and after restoration: impact of rewetting
Peak district and south Pennies (MoorLIFE project)	• Vegetation monitoring of restoration sites (quadrats, transects) • Common Standards Monitoring of restoration sites • Breeding bird surveys • student projects • species groups monitoring (e.g. bumblebees, beetles).	Peat forming species is key. SPA birds, indicator species of favourable condition. Ideally use remote sensing (can ground truth with their existing data).	• Long term data. • Lack of method for monetising peatland biodiversity • Need to have sufficient data for ground truthing remote sensing techniques • Lack of consistent way of mapping management issues – not just condition
Northern England	• Designated sites monitored for favourable condition • Key species at priority sites and simple indicators of the impacts of land management (e.g. grazing)	A fully functioning ecosystem needs to include value of habitat linkages, and to allow for transitional habitats e.g. scrub. Also may be most valuable to restore worst sites (e.g. cutover raised bogs).	• Spatial understanding of condition across (habitat networks/fragmented habitat networks). • Need to map peatland condition on a spatial scale. • Lack of data on non-designated sites.
Cairngorms National Park	• No formal monitoring programme. Surveying is on an ad hoc basis and will usually be site specific, targeting species or habitats. • Site Condition Monitoring of designated sites is biggest database • Some NVC data from 30 years ago	Park has identified 26 key species (e.g. Golden Eagle) but identified 1500 species as important to the areas. Biodiversity Action Plan species and rare habitats (e.g. montane). Al lot of important species for metric to capture.	General lack of data on peatlands particularly: • long term monitoring data • from non-designated sites • from restoration sites

Table 3.4 *Cont.*

Project Area	Biological Monitoring and Available Data	Key characteristics identified for a potential biodiversity metric	Identified Data Gaps
	• Individual landowners/managers will have data (e.g. NGO's, Forestry Commission, private land owners) but no repository for, or requirement to, share data		
Lake District & Cumbria	• Have surveyed 96 upland County Wildlife Sites (vegetation and habitat condition assessment) • Survey for key indicator species such as Sphagnum to access condition. • Targeted surveys e.g. breeding bird surveys • Generally monitoring on a site to site basis • Some staff have specialist interests (e.g. dragonflies) but surveys not standardised.	Key species: dragonflies (image used in marketing), toads, frogs, otters, ospreys. Breeding bird assemblage. Indicator species for functioning acrotelm (e.g. Sphagnum).	• Impact of peatland restoration on downstream aquatic fauna • Lack of long term monitoring for evidence of post restoration management eg. stocking densities appropriate for restored sites where acrotelm still needs to be improved • Data on restoration success, including in the context of biodiversity • Lack of long term data

The table above indicates that no single key biodiversity characteristic has been widely identified as being useful as a biodiversity metric; but that a fully functioning ecosystem based on the key ecosystem engineer, sphagnum moss, could be the foundation. In this way, perhaps sphagnum moss could be considered a keystone species for peatlands, just as wolves and beavers are keystone species for other ecosystems.

3.7 Business Sponsorship

Most UK peat restoration projects are being funded by European funds, *via* grant applications made by partnerships of conservation organisations and local agencies. Some peatland conservation schemes, both currently and historically, have been funded by national government funded schemes. The Peatland Action project[121] is the most recent example of a scheme funded by the Scottish Government, which has paid for the capital costs of peatland restoration, using the most up to date restoration techniques, at a whole country scale. Opportunities for funding also exist through the more traditional agri-environment schemes as part of Common Agricultural Policy. However, these can be difficult to apply to and do not necessarily support the most up to date or novel approaches to peatland restoration.

To date, few peatland restoration projects have been sponsored or paid for by businesses. Some examples of projects which have been sponsored directly by a business are given in Table 3.5. Each example shows the many and varied reasons for a business engaging with a peatland, usually by valuing the contribution they make to their area of interest, and some of the key messages used within a marketing and public relations context. Some businesses pay for restoration in order to create direct commercial benefits for their organisation, and others do so in order to generate indirect benefits (good PR, good staff morale). Not all the businesses given in the following examples own the areas for which they are paying for restoration (for example, South West Water does not own or tenant its catchments in contrast to Yorkshire Water and United Utilities who do own some of their catchments).

"Is a bog not just boring and muddy?"

Engaging businesses' and the general public in paying for peatland restoration is difficult (see Section 2 of this report). Table 3.5 outlines the pros and cons of some recent examples of businesses investing in peatlands and the key messages which help with communication and engagement.

[121] http://www.snh.gov.uk/climate-change/taking-action/carbon-management/peatland-action/

Table 3.5 Example Motivations of Business: why support peatland restoration? Information from individual questionnaires and presentations given at MoorLIFE conference hosted by Moors for the Future

Project location and sponsor	Motivation for business sponsorship	Marketing approaches and company commitments	Comments
Exmoor; sponsored by SW Water	Water quality (drinking water supply comes from River Exe; peat restoration will save water treatment costs and save money for consumers). Water flow regulation (peat restoration should reduce peak flows and low-flows; should allow river to be full enough for drinking water abstraction even in droughts; should reduce the need for pumped storage. Already 30% more water is being stored post restoration). Social responsibility.	Uses iconic species to promote peatlands such as: Sundew Dragonflies Marsh fritillary Skylark Red deer Exmoor ponies	"Bogs are a hard sell" "I don't think there's any one iconic species" Sphagnum would be nice at Exmoor but manage expectation as Exmoor is a grass dominated moor
North Pennines; restoration and SCaMP monitoring sponsored by United Utilities	Peatland restoration is being carried out in order to improve both water quality and to regulate water flow (reduce flood peaks and low-flows).	Landscape scale catchment management is being promoted on the UU website as Corporate Social Responsibility, to help manage SSSIs, working in collaboration with an NGO (RSPB)	"A ground breaking programme"
Peak District: land under the Arqiva TV/radio mast. Sponsored by Arqiva	Corporate Social Responsibility; customers and suppliers. Companies that react well to megatrends (like ecosystems collapse, climate change) will become market leaders.	Main message is "Giving something back"	Radio masts need to be situated on hill tops. Planning consents are presumably easier to obtain if the company is known to be environmentally responsible.
Peak District: land at Hope Construction quarries and cement works; sponsored by Hope Construction	Wants to give something back to local community CSR; leadership from Board	Sponsors a variety of festivals, events, open days, all aimed at family entertainment. Offers staff 2 days paid voluntary work Company wants to be in Sunday Times' Best Companies to Work for list. "Made in the Peak District" message	This industry sector has a high carbon footprint, yet this was not mentioned as important by the representative. Instead, it was felt that the forward thinking Board was key.

Table 3.5 *Cont*.

Project location and sponsor	Motivation for business sponsorship	Marketing approaches and company commitments	Comments
Cairngorms National Park sponsored by Cairngorm Brewery	Local identity, giving something back to local environment and community. Builds and promotes brand.	15p from each case of 500ml bottles of speciality branded beer ("Wildcat", "Autumn Nuts", "Callie" sold given to wildcat, red squirrel, and capercaillie conservations projects	Not much revenue generated?
South West Scotland and central Scotland– some sponsorship by windfarm developers	Planning consent; some developers offer to pay for restoration of equivalent peatland damaged by roads/turbines	Marketing is minimal both by developers and landowners. Negative public attitude to windfarm developments may be a hindrance to promoting peatland restoration work	Focus is on gaining planning consent? Once the peatland is developed, restoration is not valued?
Lake District National Park sponsored by local business through Nurture Lakeland	Uses voluntary donations by visitors to the regions, collected by local businesses, to fund local conservation projects. Contributing to local environment as it is a reason why tourists visit the area. Promote green tourisms Conserve the Lake District	Business's which get involved in the scheme can choose the conservation products they wish to get involved with. Projects include "Love your Lakes", "Fix the Fells", "Save our Squirrels".	One of the few existing local models for business sponsorship of habitat restoration. Transferable to a peatland restoration project should business's engage with aims and objectives of peatland restoration

3.8 Integrating Biodiversity into the Peatland Code

The brief review (above) indicates how hard it is to identify any one species, or even a suite of species, which could serve as a single biodiversity indicator for use across all peatlands. Further, if a biodiversity metric is only developed from a species-centred or numbers perspective then there is a danger of getting little insight into ecosystem function (which is all about connections). The presence/absence and abundance of keystone species does not necessarily indicate the presence/absence of a critical ecological function.

In light of the review of available data and approaches to biodiversity metrics, as well as considering the responses to questionnaires and information from peatland managers collated for this project, it is suggested that *habitat condition* is likely to be the most appropriate proxy measure of peatland biodiversity. Using habitat condition as a basis for a practical biodiversity metric under the Code would support the carbon metric (presented in Section 1) and would mean a metric could be developed from the existing robust monitoring protocols, such as CSM. Assessment of habitat condition is the most frequent form of monitoring on peatlands across the UK, with achieving good habitat condition through restoration and management the key objectives of most projects. However, habitat condition is not a "charismatic" metric and it would require efforts to communicate its value to potential investors, to ensure that the biodiversity metric helps achieve the necessary buy-in.

Set against the use of habitat condition alone is the fact that monitoring of other species is also important but for other reasons. At the local/site level certain key species or species groups may be a priority for both management and restoration and will be the driver for funding and land owner and business engagement.

Consequently, any biodiversity metric at this stage must therefore strive to recognise habitat condition as well as local distinctiveness to gain the necessary buy-in to a peatland restoration project.

It is beyond the scope of this work package to create a fully functioning biodiversity metric, but this chapter sets out a potential framework and suggests how a metric might be built. The next sections develop the concept of a biodiversity rating system which could be used by the Peatland Code.

3.8.1 Peatland Habitat condition

The approach suggested by Treweek *et al.,* (2009) for the UK involved focus on habitat distinctiveness and habitat condition. The focus on distinctiveness was required in order to compare different habitats (for example, to allow comparison between different types of woodland). However, by restricting the habitat to peatland, we remove one of the main weaknesses of the Treweek metric – the necessity of comparing (incomparable) habitats.

A peatland biodiversity metric can now be much stronger, because all it needs to assess is whether a bog is in poor, moderate, good or optimal condition; and whether the proposed management change (as per the peatland restoration plan) is likely to shift the bog from one condition to another. Treweek *et al.,* (2010) gives the Condition scores 1 (poor), 2 (moderate), 3 (good) and 4 (optimum) while for bogs, the Peatland Code has identified 5 categories: *Actively Eroding*; *Drained*; *Modified*; *Near Natural*; and *Pristine*, with the two approaches being easily integrated (Table 3.6). However, this may not provide enough sensitivity. The unique biodiversity of a bog in near-natural condition is much healthier than that of a bog in a *Modified* condition; and the biodiversity of a drained bog, although clearly healthier than an eroding bog, will differ from that of a *Modified* (burnt or over-grazed) bog.

Table 3.6 Comparison of the Peatland Code description of habitat condition and the approach developed by Treweek *et al.,* (2010)

Bog Habitat Condition	Treweek *et al.,* (2010)	Peatland Code
Bare or eroding	1 poor	Eroding/bare
With canals, ditches or grips		Drained
Overgrazed or burned	2 moderate	Modified
In good condition	3 good	Near Natural
In best possible condition	4 optimum	Pristine

Box 3.1 Vegetation structure and micro-topography indicator: a developing science?

Vegetation structure, or microtopography, or could become the basis for a standard for assessing peatland condition; it is key to biodiversity, carbon budgets and hydrological function. Indicators for microtopography have not yet been widely debated or agreed, but might in future include surface roughness/hydraulic roughness; vegetation growth characteristics; and drier/wetter patches and patterns. Microtopography is hard to demonstrate and quantify, because the science of understanding micro-topes and nano-topes is still developing. Richard Lindsay (2010 and *pers. comm.* 2015, report in prep) suggests 14 “zones” and 9 vegetation communities. These could be simplified into 4 zones, T (terrestrial ridges and hummocks), A (aquatic hollows), E (erosional forms), and Tk (tussocks) (Lindsay 2010). However, because so many of the UK’s peatlands are in poor condition, many peatlands lack sphagnum hummocks and reporting of whether the micro-topography is T or Tk dominated is not widely reported in the literature.

Microtopography has, therefore, not yet been developed for use as a common indicator of habitat quality (unlike vegetation classified using the National Vegetation Classification system and Phase I Habitat surveying); however, it has great potential for the future.

3.8.2 Peatland Habitat Connectivity

Habitat connectivity is the degree to which similar habitats are geographically linked or networked. It is relevant to biodiversity potential, and to restoration success, because it relates to the ability of species to spread to the newly restored sites. Clearly some species groups (birds, flies) will find it easy to colonise a newly restored peatland, whereas others (ground beetles, spiders) are much less mobile. A restored isolated peatland is therefore less likely to regain lost biodiversity than a restored peatland which is near other peatlands.

3.8.3 Peatland key species

There is also a need to focus on the key aspect of bog biodiversity, universally accepted (within the UK) as being beneficial to biodiversity and habitat condition: the abundance of peat forming species, primarily the Sphagnum mosses. Quantifying this key species group could be integrated into the field protocol developed for assessing Condition Categories in the field (Chapter 1) by simply adding a line to the tick sheet to ask surveyors to estimate the abundance (using a standardised approach) of Sphagnum mosses. In the future, if the protocol used multi-spectral remote sensing it might be quantified by using a proxy such as the abundance of wet mossy hummocks on the peatland – which can also be done conventionally using air-photo interpretation although requiring ground-truthing[122]. This would also have the benefit of providing a proxy of surface roughness of the peatland, which would have a positive correlation with the ability of the peatland to provide hydrological ecosystem services[123] and to raise its own watertable[124].

In addition to habitat quality, defined here as *the abundance of peat forming species and extent of appropriate vegetation composition and structure*, what was identified from discussions with peatland managers (Table 3.4) is the need for individual peatland restoration projects to monitor locally or nationally important species or species groups, as appropriate to their project, as well as aspects such as habitat connectivity.

We therefore propose a peatland biodiversity metric that blends the best of the approaches for each of the different identified key criteria identified, yet in a straightforward and easily monitored way. The proposed approach therefore combines an assessment of peatland habitat condition, peatland habitat connectivity, and key peatland species and species groups.

3.8.4 A "priority" rated system

The key objective for incorporating biodiversity into the Peatland Code, without the ability to directly assign species/habitat a monetary value, is to communicate the potential benefit to biodiversity and the wider environment of a Peatland Code restoration project. It is possible to anticipate such change *ex ante* because of the strong correlations between peatland vegetation, hydrology, habitat quality and connectedness.

The key criteria for a biodiversity metric is that it is applicable across the UK, uses habitat condition as a proxy for biodiversity and supports local distinctiveness and locally/nationally important species. It also requires a means for a project to be able to predict and state the potential positive impacts of a project as well as demonstrate project success (Table 3.7). Only by doing this will the incorporation of biodiversity into the Code act as a meaningful mechanism to promote business buy-in to the Peatland Code. As illustrated in Table 3.5 existing business sponsored conservation projects often use identifiable species to engage with their staff and customers, making this perhaps a more widely appealing concept than the carbon savings message.

By moving away from a complicated metric towards a system which recognises the potential a Peatland Code project has for enhancing habitat quality, habitat connectivity and species groups, it would allow for a simple way to demonstrate the overall potential benefit of a project to biodiversity. Table 3.7 illustrates how a project would demonstrate the potential it has to enhance each of the three measures of biodiversity potential. By meeting the criteria for one of the three measures of biodiversity potential (habitat quality, habitat connectivity and species group) a project would be awarded 1 star (bronze), if it could demonstrate it was meeting the criteria for two measures, 2 stars (silver), and by demonstrating three, it would receive 3 stars (gold). This system has the added advantage of promoting gold star projects, which may be restoring a *Modified bog* into a *Near Natural* bog, which when considering carbon alone could perhaps be less appealing as they have the lowest per hectare carbon savings. The projects least likely to score well for

[122] Dry mossy hummocks and grassy tussocks on eroding and modified peatlands can look like sphagnum hummocks from above. So surveys would need to be ground-truthed, or carried out in association with a remote sensing method that could verify dampness.
[123] Increased surface roughness, also called hydraulic roughness, has been associated with increased time to peak flow following rainstorms. Hummocky peat can therefore help reduce downstream flooding. If more research can be carried out, peatland surface micro-topography has the potential to be developed into a metric related to flood sensitivity. Richard Lindsay (pers comm 2015) is developing a protocol related to this.
[124] The ability of a wetland to raise and maintain its own water table suggests that it has been successfully rewetted, and can therefore by counted as a rewetted wetland under the proposed GHG accounting framework for the Kyoto Protocol. Sphagnum acts as an ecosystem engineer in boreal peatlands, rapidly forming an environment (hydrological, biogeochemical) where its own success is facilitated. The peat properties and the plant composition dynamics are largely governed by the features of Sphagnum (Waddington *et al.,*2015).

biodiversity could be at sites which are being restored from the worst habitat condition, such as restoring a bog from *Actively Eroding* to *Drained*, although these projects would generate the greatest carbon savings and be most appealing for emission reduction objectives. Therefore a balance is struck between different types of restoration projects and the benefits they will have.

One disadvantage of using any rating system is the difficulty in setting thresholds for the key criteria. For example, there are difficulties in establishing the biodiversity consequences of habitat networks and connectedness. Defining the categories below (Table 3.7) as a simple yes or no, as opposed to defining levels for each, addresses the problems in defining thresholds and still sufficiently predicts projects which will have the greatest potential for improving biodiversity.

One advantage of using habitat quality as a feature of a metric is that it can also be used for the other key ecosystem services provided by peatland (Table 3.8). The presence of sphagnum hummocks could potentially be used as a proxy for several ecosystem services. Ultimately the benefit of a restoration peatland restoration project on all Ecosystem Services could be encapsulated by a “star” system (Table 3.9).

Table 3.7 Illustration of how the measures of biodiversity potential: habitat quality, habitat connectivity and species groups, suggested as the basis for the approach to incorporating biodiversity into the Peatland Code, could be demonstrated by a project.

Potential to Enhance	Evidence Needed to Demonstrate Project Potential
Habitat Quality (appropriate vegetation composition, structure and micro-topography)[125]	Presence of sphagnum. Presence of hummocky sphagnum micro-topography. Evidence (photos/maps) that shows appropriate bog vegetation exists at the site and that restoration will provide the necessary conditions for its expansion. This can come directly from the Peatland Code field protocol used to identify the Condition Categories (and Emissions Factor) of a site as well as the already required initial desk based aerial survey work.
Habitat Networks	Maps and aerial images showing site connectivity and links to existing bog habitats/peatland restoration sites/designated peatland sites etc. This could come from the air photo analysis required prior to using the Peatland Code protocol.
Species Groups	Evidence that project will target and support habitat provision for one locally or nationally important peatland species or species group (Table 3.2).

Table 3.8 Which potential peatland biodiversity metrics have most potential for the other peatland ecosystem services?

Metric	Carbon	Biodiversity	Water quality	Flood regulation
Habitat Quality (Sphagnum)	yes	yes	yes	yes
Habitat Networks	no	yes	no	no
Species Groups	no	yes	no	no

[125] Sphagnum hummocks; not tussocks or dry mosses

The extent to which water quality and flood alleviation depend upon habitat network connectedness depends on the context: where the networks are and how the water flows through the catchment. Therefore we suggest in Table 3.8 that habitat networks cannot yet be used to predict water quality and flood alleviation because responses are so site and context specific. Further work on key catchments would be helpful.

Table 3.9 A rating system for the benefits of a restoration project for carbon, biodiversity and other Ecosystem Services.

Ecosystem Service	Bronze	Silver	Gold
Carbon	< than xxx tCO_2eq/per project	< than xxx tCO_2eq/per project	> than xxx tCO_2eq/per project
Biodiversity	Meets one of the biodiversity objectives	Meets two of the biodiversity objectives	Meets three of the biodiversity objectives
Water Quality			
Flood Mediation	To be developed		
Cultural			

A biodiversity rating system like the one above is not necessarily the best solution for measuring biodiversity on peatland but it is the most practical solution available at present.

3.9 Conclusions

The approaches to biodiversity metrics outlined in this chapter can, to some extent, be adapted for use with the Peatland Code. They indicate that peatland habitat condition is the key characteristic to indicate biodiversity quality, and suggest it is hard to identify any one species, or even a suite of species, that would be a useful biodiversity indicator for all UK peatlands. A rating system could be devised which would allow comparison of sites; and although this would not be fully quantifiable, it might be the starting point for a win-win-win-win strategy to compare 4 key Ecosystem Services provided by peatland: carbon, water quality, flood regulation, and biodiversity. However, cultural services would be hard to value using habitat quality as a proxy.

3.10 Recommendations for Further Work

In order to integrate biodiversity into the Peatland Code, particularly to take the mechanism to do this beyond a rating system described here, further evidence has to be gathered for the impacts of peatland restoration on biodiversity. Recommendations given here were common responses from those interviewed when researching this part of the project:

- There is a need to encourage and support long term monitoring. The lack of funding for biological monitoring is the primary barrier to monitoring peatland biodiversity and impacts of restoration
- Encourage and co-ordinate consistent monitoring across regions: develop monitoring protocols which can be used by peatland managers and researchers to ensure data is collected from across the UK from a wider range of sites

- There is a lack of empirical evidence on the multi-benefits of peatland restoration on other key ecosystem services such as water quality and downstream flooding. These are significant issues for people and industry and by showing positive impacts of restoration on these key issues is regarded as being a significant driver for peatland restoration in the future

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Section 3: Quantifying the potential biodiversity benefits of peatland restoration projects under the Peatland Code

Section 4: Scoping the Natural Capital Accounts for Peatland

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4.1 Summary

This section scopes the development of a peatland account within the developing UK environmental accounts, and forms Work Package 3 of project NR0165. It has drawn on the material in NR0165 (Smyth *et al.,* 2014), and in developing work on UK environmental accounts, in particular that for woodlands (by eftec and partners), wetlands (under development by ONS), and the UK greenhouse gas inventory (by CEH, JHI and CCC for DECC).

Whilst this scoping study has informed developing work by ONS on a UK Wetlands account, the interaction between peatland and wetland[126] accounts is yet to be fully resolved.

Key issues for development of the peatland account are the need to agree a peat base map (showing the extent of peat) in order to make an accounting split between peat and non peat, and then to assess the condition of that peat. Because the land cover maps are not sufficiently detailed, other data (from ongoing country-wide peatland mapping work) need to be used and correlated with the maps to ensure consistency with the wider UK natural capital accounts. This may mean adjustment to other asset classes (e.g. woodlands, wetlands) to avoid double counting.

The distinct ecosystem services (ES) provided by peatland mean that it is essential to treat it as a distinct asset within the accounts. This paper suggests having a peatland asset class, in order to bring together relevant data and assist with peatland management policies. (The less preferred alternative approach is to include peatland as a subclass in other assets; e.g. woodlands, wetlands). The differences between these approaches are mainly presentational, as the same data will be needed in either approach. If peatland was added to other asset accounts (e.g. wetlands) but not identified as a distinct subclass of asset, this would likely significantly misrepresent the services it provides, which vary compared to other types of wetlands (e.g. carbon regulation).

The key services provided by peatland are:

- **Food**, both intensive crop production from drained lowland peatlands and extensive livestock grazing on upland peatlands. Intensive agricultural use of peat depletes the peat resource.
- Peat extraction[127]. An estimated 0.8 million cubic metres of peat in the UK is extracted each year for horticultural use. This results in carbon emissions and loss of the peat resource. Long term policy commitments are for it to be phased out.
- **Water quality regulation**. Water quality regulation has a substantial value, and water companies place a higher value on receiving water with minimal organic carbon than they do for peaty water coming from gullied or drained peatlands. Although this service cannot be accurately valued at present, valuation may be feasible with further research.

[126] The IPCC terminology roughly splits wetlands into peatlands (but including drained organic soils which have been converted to other land-use), coastal wetlands (in the UK this would be saltmarshes) and 'other wetlands', which equates to freshwater wetlands on mineral soils.

[127] An extraction rather than a sustainable service, since peat cutting is faster than peat growth.

- **Climate regulation**. The focus of the account is on measurement and quantification of fluxes (i.e. the changes in greenhouse gas emissions) rather than on the size and value of the substantial stock of carbon stored in peatlands[128]
- **Flood management** and river flow regulation has a value, although the science on this is still developing.
- **Recreation** is known to be significant from case studies, but needs to be valued systematically as part of analysis of recreational values of all UK habitats within the national natural capital accounts.
- **Biodiversity**. Biodiversity is difficult to value, so at present is best treated as a characteristic of peatlands, a supporting service which also provides cultural benefits.

It is suggested that biodiversity, flood management and water quality are part of the accounts, but that the values of these services and other services that are difficult to value (pollination, archaeological preservation, soil formation etc), may need to be excluded from the account to begin with, due to lack of suitable data or metrics.

The main characteristic to the delivery of those ecosystem services is peatland condition: the vegetation, drainage and/or erosion of peatlands. There is a good level of co-variance, in that climate regulation, water quality, water flow regulation, and biodiversity are all linked to peatland condition in the same way: good quality ecosystem services are provided by peatland in good, undrained condition. However, arable and horticultural food crops are best produced from peatland that is heavily drained and fertilised. A bottom-up construction of the account, based on areas of peatland in different condition, is therefore the recommended route to developing the peatland account. Water quality, water flow regulation, recreation and biodiversity vary spatially, so would benefit from spatially disaggregated accounts. The data to achieve this is not all available at present, but should be available by 2020.

4.2 Context: Defra/ONS guidance for developing ecosystem accounts based on broad habitats (June 2014).

The steps involved in conducting scoping studies and compiling initial accounts for a particular Broad Habitat, based on Defra and ONS experiences so far and the World Bank's report on designing ecosystem accounting pilots[129], are as follows:

1. **Define extent.** Define the different ecosystems/habitats covered within the Broad Habitat category and assess the available and likely future availability of measurements of the extent of each habitat
2. **Identify key services**. Identify the key services these ecosystems provide and their importance and status by reference to the prioritisation criteria
3. **Establish relevant characteristics**. Identify what characteristics are key to the delivery of those services (this might best be done in consultation with experts)
4. **Assess data sources**. Assess the availability (including expected future availability) of non-monetary information on those characteristics and those services, and the degree to which spatially disaggregated data is important for the accounts and its availability

[128] Deep, water-logged peat is an unfossilised coal seam, it only affects climate when its carbon comes out of storage.
[129] https://www.wavespartnership.org/sites/waves/files/documents/PTEC2%20-%20Ecosystem.pdf

5. **Propose asset account structure**. Conclude on the services which should be included in the initial accounts and hence on the structure of the non-monetary asset accounts in terms of recording specific habitats separately and the relevant characteristics for those habitats
6. **Propose services account structure(s)**. Conclude on the units and structure of the non-monetary services accounts for each of these habitat types
7. **Spatially disaggregated accounts**. Conclude on the scope for spatially disaggregated non-monetary asset and services accounts and the process by which they should be compiled and maintained
8. **Assess valuation options**. Explore options for the valuation of those services (and hence the asset value relating to those services)
9. **Provide proof of concept**. Set out illustrative accounts on the basis of the data obtained so far and make recommendations about a) how to best fill data gaps b) when to update and c) how to reconcile with other accounts
10. **Unresolved issues**. Set out any unresolved (specific or cross-cutting) issues arising which need further consideration, and report any potential policy applications identified in the course of the study
11. **Resource requirements**. Assess the resources and time required to compile the proposed accounts and resolve outstanding issues

As an initial pre-scoping and discussion exercise, this section uses the approach above as a framework, but recognises that a more detailed paper will be required in due course, once the main classification has been agreed. It begins with the classification system itself, and then briefly addresses steps 1-4 and steps 10 and 11. Steps 5-8 are commented on. Step 9 (proof of concept) is beyond the scope of this project.

4.3 Classification of Peatland Asset

The proposed approach is that a standalone account for peatland (either as an asset class or a subclass within a larger asset) is required and will be distinct from other asset classifications (e.g. floodplain, uplands) even if it is handled as a sub-class of those assets within the overall structure of UK natural capital accounts.

> *An alternative approach is that peatland is identified as a subclass within a number of other asset classes (i.e. woodland on peatland, agriculture on peatlands, etc with a wetlands account only including undrained peatland). This classification would result in re-wetted peatland moving between asset classes e.g. from uplands (or mountains, moorlands and heath using UKNEA terminology) to wetlands. This is not ideal as it could suggest a change in the make-up of the UK's natural capital, whereas the actual change is one of management.*

Peatland is defined as the presence of deep peat soils according to national definitions[130], i.e. organic soils of at least a minimal depth. However, as depth of peat soil is not usually known with accuracy, and many peat soils extend significantly deeper than this, any depth estimate is only a guide for those identifying the presence of peatlands.

Peat ceases to function as peatland where it is extracted or converted to intensive agriculture; and it functions less well where it has partially lost its peat-forming vegetation, or where it has become

[130] Data are compiled using a definition of 'deep peat' of 40cm deep in England, and 50cm in Scotland, but in reality they represent estimates of the same characteristic, i.e. peat that is deep enough to function as a peatland in that it is peat-forming.

shallower due to desiccation and contraction/subsidence (e.g. on over-grazed or over-burnt sites); or erosion (either gullies, affecting a comparatively small area, or sometimes more widespread surface erosion). However it is unlikely that the extent of peat will change significantly at a landscape scale within the next fifty years[131].

Where the peat-forming vegetation is lost, most of the functions of peatland decline and may eventually be lost, impacting the value of ecosystem services from the natural capital. Peat can be treated like water or air: its quality is easier to measure than its quantity. Changes in vegetation and peatland condition are therefore important to detect within the data on extent of peatland in an account.

UK peatland occurs in both the lowlands and the uplands. Under LCM2007 it would be classified within the "Fen, Marsh, Swamp; Bog; Freshwater" category. But under the UK NEA class, raised bogs and fens (which occur mostly in the lowlands) might be classified as "Open water, wetlands, floodplains", whereas Blanket bogs might be classified as either wetlands or as "Mountains, moorlands and heaths" (MMH).

Variations in condition mean that peatlands can move between these classifications within a few decades. For example, some raised or blanket bogs can dry out (due to drought and/or drainage), and become 'heaths'. Sometimes these can be restored back to 'bog' (i.e. wetland) status by raising water levels. Such short-term fluctuations in the characteristics of an asset need to be reflected in natural capital accounts, because they are an important determinant of ecosystem services value (see below), including the carbon balance. However, this should not be done by changing the natural capital asset classification for the unit of land (i.e. from peatland to heath/moorland and then back to peatland). The key underlying feature of the asset class is its peatland soil. It should therefore be classified as peatland, and the short-term variations in its characteristics (drained/undrained) should be handled through changes in its characteristics, reflected in subclasses of the peatland asset (much as woodland can be subdivided into broadleaved/coniferous, native/alien species).

It should be noted that the approach to accounting for woodland does not fully account for forestry impacts on soil carbon. However, forestry plantations on peatland should account for any damage to the peat (or its carbon) as a result of the drainage, ploughing, and growth of a forest crop. (Note that such forestry operations differ from natural wet woodlands on peat soils, which are a special case, and are so rare in the UK as to be on the UK red list of priority protected sites[132]. Wet (bog) woodlands are rare enough to exclude from the account at present.

In conclusion, it is essential from a natural resource management perspective to distinguish peatland as an asset class, either on its own or as sub-classes of other relevant assets, in the UK natural capital accounts. Peatland having its own account is best for peatland management. This account would need land use sub-categories (arable, forestry plantation, intensive grass, permanent grass, rough grazing, heath/moorland conversion[133], peat extraction, near natural), with near-natural then subdivided into blanket bogs, raised bogs, swamps, fens etc. The advantages of this approach are that peat would become less ignored as an important ecosystem and climate driver, and that there would be more focus on effective policies to protect the peat resource.

[131] It is theoretically possible that peat extraction in a lowland raised bog could remove all peat, however in practice, the companies should cease extraction before they hit mineral soil, and usually stop when they reach fen peat because it isn't marketable. Most existing peatlands are over ten thousand years old (suggesting very slow change in extent); however some districts may have lost some of their deep peat as a result of historic or prehistoric peat cutting, burning and grazing; and some regions (blanket bogs in England) seem at greater risk of slow loss of peat depth than from loss of peat extent.
[132] http://jncc.defra.gov.uk/protectedsites/sacselection/habitat.asp?FeatureIntCode=H91D0
[133] Assuming 'grass/grazing' categories are areas where land cover is predominantly grassy and grazing animals are common; whereas heath/moorland classes feature abundant ericaceous cover with low grazer density)

The alternative is to work with the NEA classes so that blanket bog stays in MMH, and the rest of near-natural peatland goes into wetlands, and modified peatland sites in other accounts (under agriculture and forest). Peatland assets would therefore be present as sub-classes of assets in several different places in the account, following the subdivisions (arable, forestry, intensive grass, permanent grass, rough grazing, near natural) described above.

If peatland was added to other asset accounts (e.g. wetlands) but not identified as a distinct subclass of asset, this would likely significantly misrepresent the services it provides, which vary compared to other types of wetlands (e.g. carbon regulation). It is also much easier to keep track of the peatland assets if they are all in one place rather than having to compare numbers in multiple separate asset classes. For example, it has recently been argued that misattribution of riparian wetland water quality (WQ) regulation functions to blanket bogs led to an orders-of-magnitude over-estimate of the value of UK wetlands for WQ regulation in the NEA.[134] It is therefore recommended that peatland should be treated separately rather than be added to the other asset accounts.

It is not within the scope of this preliminary exercise to provide a logic chain for peatlands summarising characteristics and services or to provide an accounting structure; however we have begun to sketch out what an accounting table would look like for peatland ecosystem service provision (Table 4.1)

Table 4.1 Sketch of a potential accounts structure

			Type of ecosystem		
			Peatlands		
			Flow (Annual, 2012)	Profile of Flows ('20' yrs)	
Provisioning	Food	Livestock grazing	£		
		Cropping/horticulture	£		
	Fibre	Wool	*minimal*	-	-
		Peat extraction	0.8 million cubic metres		
		Timber	*0 (already in woodland account)*		
Regulating	Greenhouse Gas Flux		*20 MtCO2 (use figures from DECC)*	*0.5 MtCO2 (20 yrs; 2012-2031)*	*MtCO2 (20 yrs; 2012-2031)*
	Water quality regulation		*Difficult to measure in physical and monetary terms, but may be possible to model change in DOC*	*Difficult to measure in physical and monetary terms*	
	Flood and flow management		*Difficult to measure in physical and monetary terms (HM Government, 2014)*	*Difficult to measure in physical and monetary terms, but may be possible to model changes as a result of peatland condition improvement*	
Cultural	Recreation				
Supporting	Biodiversity		*Difficult to measure in physical and monetary terms (HM Government, 2014)*	*Difficult to measure in physical and monetary terms … but could link to changes in peatland condition class*	

[134] Investing in nature: Developing ecosystem service markets for peatland restoration, *Ecosystem Services, Volume 9, September 2014, Pages 54-65,* Aletta Bonn, Mark S. Reed, Chris D. Evans, Hans Joosten, Clifton Bain, Jenny Farmer, Igino Emmer, John Couwenberg, Andrew Moxey, Rebekka Artz, Franziska Tanneberger, Moritz von Unger, Mary-Ann Smyth, Dick Birnie

4.4 Extent of Peatland Asset

Peatlands occupy around 10% (23,000 km^2) of the UK's land area (JNCC, 2011). Within the UK, the largest proportion of deep peat area is located in Scotland, however significant areas of peat exist in all four countries. Blanket bogs comprise around 83% of the total peatland area[135], but raised bogs and fens also occupy significant areas, as do 'wasted' deep peats in lowland England now used for intensive farming. Natural peatlands grow continually over thousands of years, and have a net global climate cooling effect over the long term (Frolking *et al.,* 2006), while at the same time providing a number of ecosystem services. Some of the ecosystem services are provided by the stored peat itself (e.g. peat's use as a fossil fuel, as a soil to be drained for agriculture, or as stored carbon); whereas ecosystem services such as climate regulation, water quality regulation, flood regulation, and biodiversity depend on the presence of a living, peat-forming surface layer of vegetation and water; i.e. a healthy, active peatland.

Across many parts of the UK, the ecosystems services provided by agriculture, forestry, sport and fuel from peatland have been more highly valued than the climate, water and biodiversity services. The extent of peat in the UK today may therefore be smaller than in the past, and there is certainly a smaller area of active peatland now than in the past.

The extent of the stock of peatlands in the UK is not precisely known, being measured differently under different definitions and methods deployed to develop different data sets. Key data sources are the Land Cover of Scotland 1988 (LCS88), Land Cover Map (LCM) 2007, the Countryside Survey (CS), national soil surveys and the British Geological Survey (BGS). These sources have different levels of accuracy and peat definitions, and are used in different combinations in different parts of the UK to establish overall peatland cover[136].

Using the LCM2007 may create problems for peatland definition in that, as a land-cover map, it does not always classify land according to soil type. Although some (wetland) landcover classes are specifically associated with the presence of peat, areas where peat underlies other land classes such as coniferous woodland or arable land cannot be distinguished from areas of the same land-use on mineral soils. Furthermore, the LCM2007 does not always detect small areas of wetland within mixed landscapes, does not always classify them correctly, and sometimes subsumes them within larger non-wetland polygons. This is a particular problem for the identification of near-natural fens. The CS gives more accurate data for individual surveyed areas, but is based on a sample, so is not spatially complete. LCS88 gives complete data at a good resolution, but only covers Scotland, and is now 25 years old. Because there is no UK map, each part of the UK has produced its own version of maps of peatland extent. Table 4.2 outlines best estimates, as per interim reports for NR0165.

[135] JNCC 2011. Towards an assessment of the state of UK peatlands, Joint Nature Conservation Committee Report No. 445. Peterborough.
[136] Evans et al 2014; in preparation for DECC: "Scoping the use of the methodology set out in Chapters 2 and 3 of the '2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands in the UK GHG Inventory: Land Use, Land Use Change and Forestry (LULUCF)"
https://online.contractsfinder.businesslink.gov.uk/Common/View%20Notice.aspx?site=1000&lang=en&NoticeId=1501372. This project is developing the methodology for reporting on peatland drainage and rewetting in the LULUCF inventory, and is compiling some of the required information on area and quality of peat, as well as the climate regulation ecosystem service.

Table 4.2 Best estimates for peatland extent – Data sources

Country	Data Source	Peat area (ha)	Comment
Scotland	JHI unified peat map	668,324	Based on JHI/Macaulay Land Use Research Institute 1:25,000 National Soil Map of Scotland, augmented by 1:250,000 National Soil Map of Scotland (1982)
England (upland)	Natural England (2012)	1,692,744[137]	Based on NSRI, BGS and Natural England mapping data
England (lowland)	BGS superficial deposit map		Lacks information on 'wasted' shallow peats, so may be better to use RSRI map
Wales	NRW/BGS Wales Unified peat map	89,876	Based on BGS and Natural Resources Wales mapping data
Northern Ireland	1988 Peatland Survey BGS superficial geology and AFBI histosol soil survey map of Northern Ireland	195,364	Geological Survey of Northern Ireland 1:50,000 mapping still in progress for Mourne mountain peatlands. 1:10 000 BGS DiGMapNI with added 1:25 000 AFBI soil survey map.
total		2,646,308	

The definitive country by country maps of peatland extent are still under development, but should be available in time to inform an account well before 2020. Once finalised, these should be a relatively stable basis for developing the peatland account, although they will need correlating with the data used to define other assets in the UK accounts. Work of this nature is underway for the Welsh Government, using aerial survey and condition survey data, and in Scotland where satellite data is also being used. Similar work is likely to be needed in lowland England and Northern Ireland. All of these issues are being addressed by the ongoing DECC project, in order to provide a functioning inventory methodology.

Once established, more accurate data on the extent of peatlands will need to be related to the LCM2007, through an analysis of overlaps. The LCM2007 does not provide a direct quantification of peatland area, and therefore significant adjustments will need to be made, reducing areas of other natural capital assets (to ensure that the areas of different assets continue to add up to the area of the UK). An alternative way to handle this overlap between asset classes (e.g. the presence of woodland on peat soils) is to restrict the woodland account to above-ground processes, and account for the subsoil services from peatland separately, in the peatland account. However, it is felt that this treatment could be confusing for data users, and would require explanation of why services were not being double counted, even though the areas of assets did not sum to the area of the UK.

The Principles of Ecosystems Accounting paper (Defra and ONS 2014) suggest that ecosystem accounts should be constructed around the categories of the LCM, but that where there are more

[137] A range of figures have previously been published and challenged; this is our present best-estimate, sourced from Evans et al 2014.

detailed and relevant data available on land use, these should be used instead, with the results reconciled with the LCM.

With these data in place, a simplifying assumption, that the extent of peatland doesn't change significantly each year, can be made. Changes in extent of peatland can occur, as noted elsewhere, but are only likely to be significant to the account over decades, and therefore regular re-calculation of the extent of peatland is unnecessary for accounting purposes. The annual peatland account will therefore show fluctuations in value as a result of management changes.

It is important that the accounts (however they classify peatland) identify different land uses on peatland (e.g. drained; cropped; afforested). Otherwise the account will ignore modified areas of peatland and only include what is in good condition, thereby heavily biasing the account.

Calculating the volume of peat requires measurement of the depth, bulk density and extent of peatland. Peat depths and bulk densities are largely unknown, and are not always relevant to ecosystem service delivery. Peat volume cannot therefore be included as a reliable characteristic of the asset in developing the account. Peatland condition is a much more helpful measure.

4.5 Condition of the Peatland Asset

Only a small part of the total UK peatland area is believed to be undisturbed by atmospheric pollution or land-management (e.g. Natural England, 2012). Pressures linked directly to land-management include drainage, conversion to other land-uses including intensive grassland, cropland and plantation forestry, low-intensity stocking with domestic livestock or deer (grazing and trampling) and moorland burning, primarily for rearing red grouse.

Various condition categories are used to assess peatland condition, and each are designed to work at different scales, and for different purposes[138]. A list of potential condition categories suitable for use in greenhouse gas calculations includes:

- Bog - Near natural (vegetation not modified by human management)
- Bog – modified (could split into heather/grass dominated, and/or burnt/grazed)
- Bog – drained
- Bog – eroding
- Woodland – conifer – on peat
- Woodland – broadleaf - on peat
- Improved grassland on peat
- Cropland on peat
- Fen - near natural
- Fen – modified, scrub-covered
- Peat extraction
- Rewetted bog
- Rewetted fen

All of these would also prove suitable for use in classifying other ecosystem services.

[138] for example, the Peatland Code conditions (Smyth et al 2014, work package 1 of this contract) are designed to show changes in condition and to be monitored on the ground and from remote images, JHI (for CxC, http://www.climatexchange.org.uk/reducing-emissions/carbon-benefits-peatland-restoration/) is designed to work with LCS88 data, IPCC (2014a, 2013 Supplement to the 2006 IPCC guidelines for national greenhouse gas inventories: Wetlands) uses global categories, some of which are less suitable for UK.

Landcover maps are helpful in respect of the possibility of mapping peatland condition (which is reflected in peatland vegetation), but are troublesome where land-cover and soil-type gradients (rather than sharp boundaries) occur, for example where heathery peat grades into heath, (i.e. in areas of thinning peat, peaty pockets, and degrading peat, where peat depth could be insufficient for it to be classified as peat). In practice a complex combination of relevant data sources need to be used. In future, satellite or aerial images coupled with automatic image analysis are likely to prove more efficient.

Our project team is in the early stages of assessing the most appropriate data sources for use with LULUCF (Evans *et al.,* 2014). Further work is required, ideally including input from the key people in the agencies, but initial findings suggest the following in Table 4.3.

Table 4.3 Initial assessment of potential data sources on peatland condition

Data source	Definitions, relevance	Pros and Cons
LCM 2007	Less detailed than LCS 88, so can't compare (eg) Near Natural peat; LCM says 'grass dominated' or 'heather dominated', without considering *Sphagnum*. Uses different habitat categories to LCS 88 (e.g. grassland)	Not helpful enough for indicating peatland condition. Cannot compare LCS88 with LCM 2007; different definitions and resolution.
LCS 88	Has a large number of categories for modifications such as burning and erosion 'Eroded' Includes both active and inactive erosion features	Scotland only. Has best resolution. May over-estimate actively eroding areas, need to ground-truth. Cannot compare LCS88 with LCM 2007
Natural England (2012)	Splits 'upland' (moorland, i.e. not forested or agriculturally improved) from 'lowland' using the 'moorland line'. Upland peat map based on NSRI, BGS and Natural England mapping data Condition classes: 'unclassified' implies no visible erosion, ditching or burning, but does not mention where natural vegetation has been modified by grazing/management. Suggests 15% English blanket bog is drained	England only. Only covers upland peat. The 'unclassified' category indicates the absence of visible features, but does not necessarily indicate good condition. Effectively this class includes both *Near Natural* and *Modified* peatland according to the classification above.
JNCC(2011) peatland assessment	A collated assessment for each of the four countries. Finds more fens than LCM	The English data are from a separate peatland assessment by NE (Natural England, 2010); however the data are presented more completely in the JNCC report than in the NE report.
IACS	Would provide information on management change as a result of agri-environment schemes	Land parcels used for IACS reporting do not necessarily coincide with peatland boundaries, which may lead to misleading estimates of stocking density, crop type and management change on peat areas within larger land parcels. Using IACS data also leads to spatial biases because more small peat areas are detected in areas mapped at higher resolution

Table 4.3 *Cont*.

Data source	Definitions, relevance	Pros and Cons
Forestry Commission (from CARBINE carbon accounting model)	Includes all FC forestry, but seems to miss some private conifer forestry on peat and some broadleaves on peat (e.g. fens)	Need to amalgamate with other sources, e.g. LCM or CEH/JHI 'unified' maps
Countryside Survey	Only covers a sample, although intended to be statistically representative of the overall habitat area.	Spatially incomplete
ClimateXChange (Chapman *et al.*, 2012)	Based on LCS88, LCM2007, Forestry Commission data	Scotland only.
Get Mapping, GoogleEarth maps and other Satellite imagery	None yet, would need to write programmes relating landcover to peatland condition. Is used by LULUCF inventory.	Image dates can be inaccurate.
Directory of Mines and Quarries	Peat extraction data available after 2002, when they began listing it	Use this to identify sites, then use Google Earth to measure area
Compendium of Peatland restoration projects (IUCN/ Defra) http://www.peatlands.org.uk/	Lists peatland restoration projects as reported by project partners, who fill in a questionnaire. Provides variable information on type of peatland, location, hectares, and works done, from which peatland condition can be inferred.	Some projects provide more information than others. Risk of double counting; parts of some projects are reported more than once. This disaggregated (bottom up) datasource is the best available data source for peatland restoration at present.

Deciding on the best data source depends on what data required, and for which country. Most of the aggregated (top down) datasets are more appropriate for identifying historical (e.g. 1988) peat vegetation (and hence peatland extent), but few are specifically suitable for assessing present peatland condition. The IUCN Peatland Compendium provides the best source of disaggregated data, but its accuracy needs to be improved by an additional layer of editing (to avoid double counting and to add data from certain absent projects) and supporting spatial information such as GIS layers describing the extent of restoration activities. The best way to access data from the whole UK, e.g. to assess the results of widespread agri-environment de-stocking from peatlands, would be to develop peatland condition metrics (e.g. WP1 of this contract) and relate them to remote sensing imagery.

Box 4.1: Improving data on Peatland Condition

There is potential to map peatland condition more accurately through the use of more frequent aerial surveys and satellite data. Aerial and remote surveys provide useful data on peatland condition in Scotland[139] and Wales (not yet published) and some high-priority catchments in Scotland.

Aerial survey is currently an expensive way to generate data on peatland condition, due to the computing and staff capacity needed to extract relevant information from the raw data, but a level of automation may soon be possible; for example in identifying areas with drains, or areas with eroding gullies. Between these surveys, monitoring could focus on where changes to peatland

[139] Chapman (2014) Report on peatland mapping of the resource and its condition in the UK – Scotland http://www.iucn-uk-peatlandprogramme.org/sites/www.iucn-uk-peatlandprogramme.org/files/ReportsonPeatlandMapping_SChapmanetal.pdf

Box 4.1 *Cont.*

extent and/or condition are known and/or suspected to be happening, such as at peat abstraction sites, or peatland restoration projects.

For satellite data, the technology (i.e. satellite capacity and accuracy) and techniques (methods to use satellite data) are still developing. This may provide an efficient means of monitoring condition of peatlands and identifying where restoration has occurred. Work is ongoing in Scotland to verify modelled peatland condition from satellite data (funded by climateXchange Scotland).

This ongoing research is promising in terms of providing improved data to populate the UK natural capital account for peatland. However, it is not always focussed on key issues for the account (i.e. the need to reduce overall errors in the extent, stock and services, in periodic measurements). Therefore, there is likely to be a need for further research to re-scrutinise results for the purpose of reducing errors in national data for the peatland account.

On-going research into the extent of UK peatlands has not focussed on the key issues for a peatland account (i.e. minimising errors in data on extent and likely changes to that extent), and therefore further research will be required; see Box 2 below.

Box 4.2: Peatland Accounting within the Greenhouse Gas accounts

The text in this box is quoted from Evans (2014) interim report to DECC. It illustrates the recent shift of wetlands and peatlands from the periphery to the focus of international greenhouse gas accounting, and indicates its future importance in the UK.

Although the importance of GHG emissions from degraded peatlands (and other wetlands) is now recognised, structures to account for these emissions within the United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol reporting structures were not previously well developed. Although Wetlands appear as a reporting category in the 2006 IPCC guidelines on Agriculture, Forestry and Other Land Use (AFOLU; IPCC, 2006), the hierarchical reporting structure meant that land would only be classified as a wetland if it did not fall into any of the other major land-use categories (i.e. Forest Land, Cropland or Grassland). In practice, this meant that the only wetland management activity reported under Wetlands was peat extraction, alongside emissions from flooded lands. Although provision was made for reporting of emissions from drained peatlands (generally referred to as 'organic soils') under Forest, Cropland or Grassland, the Tier 1 methodology presented in the 2006 guidelines for organic soils was highly simplified, and received relatively little attention. Furthermore, no provision was made for reporting of emissions reductions as a result of wetland re-wetting.

Partly as a consequence of the lack of prominence given to peatlands and organic soils in the 2006 guidelines, activities relating to peatland drainage and re-wetting were not prioritised in national inventory assessments, including that for the UK. With growing recognition of the importance of peatlands as a GHG emission source (second only to deforestation in the land-use sector), it was recognised that improved accounting methods and reporting structures were required for wetlands in general, and for peatlands in particular. This led the UNFCCC to establish an IPCC working group in 2011 to compile a new 'Wetland Supplement' to the 2006 Guidelines, which was completed in 2013 and published in early 2014 (IPCC, 2014a). The Wetland Supplement provides a new and far more detailed methodology to account for GHG emissions from peatlands in all land-use categories, including emissions from drained organic soils under Forest land, Cropland and Grassland, and

***Box 4.2** Cont.*

(reduced) emissions/sequestration following peatland re-wetting. Alongside this assessment, the UNFCCC established Wetland Drainage and Rewetting (WDR) as a new activity which parties can choose to report on for the second commitment period of the Kyoto Protocol (KP), and the IPCC published the 'Kyoto Protocol Supplement' (IPCC, 2014b), providing updated methods for a range of KP reporting areas, including the new WDR activity.

In 2013 the European Union made a decision (EU/529/2013) to move to mandatory reporting of GHG emissions and removals for Cropland Management and Grazing Land management under the Kyoto Protocol second commitment period, 2013-2020. The UK will soon decide whether to elect WDR as an additional reporting activity.

4.6 Subdivision of Peatland Assets

Within the Peatland Asset account, careful subdivisions of the asset are needed to reflect key characteristics that drive the value of the stock and flows of ecosystem services. We suggest a tiered classification of the peatland asset to help with accounting, as shown in Figure 4.2. As discussed above the 'peat' class is more or less fixed, and subdivided into bogs and fens. Land-use class would sit below this, and can then be further subdivided according to management. Key management classes are probably drainage, burning and grazing (plus re-wetting and restoration) in bogs, and intensive (commercial farming) *versus* extensive (conservation wet meadow) grassland management in fens. An important consequence of management in upland bogs can be erosion.

It must be recognized that there are some interactions between these data layers. For example, land use classes can be equated to peatland condition (e.g. in Scotland, the presence of forestry on a peatland is assumed to mean that the peatland is drained).

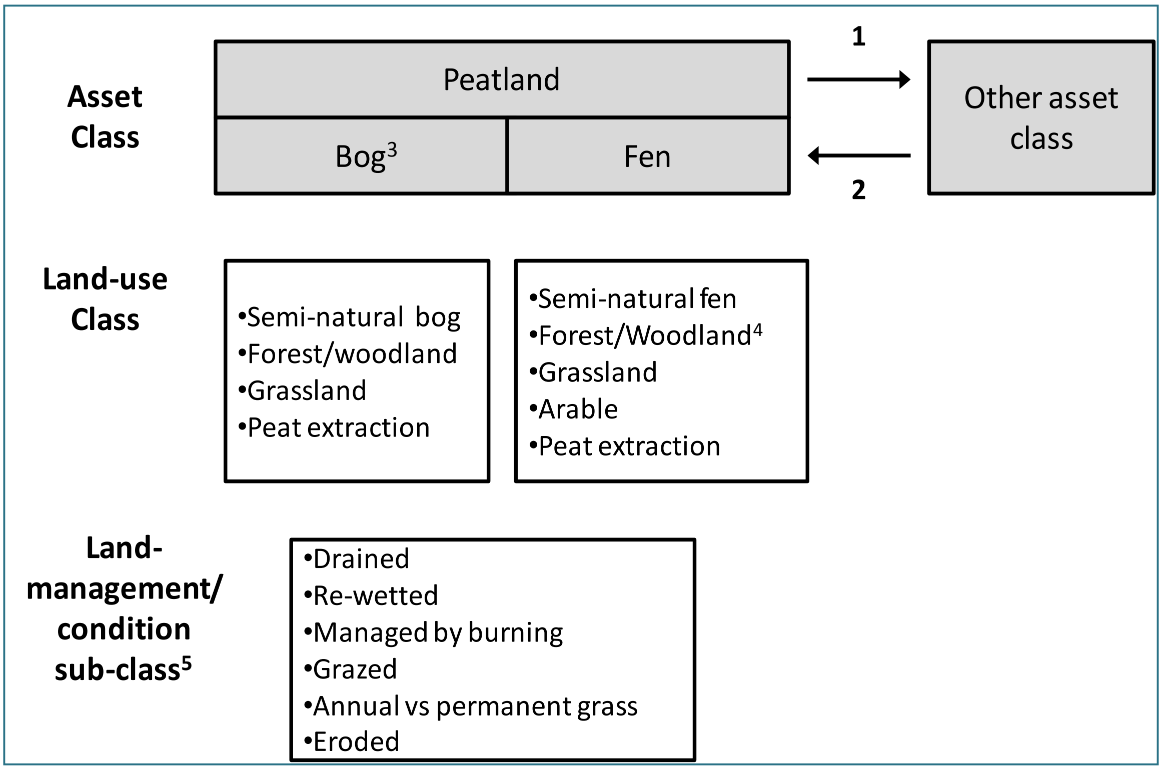

Figure 4.2 A suggested tiered classification of the peatland asset.

Notes:

1. Shift between classes when level of peat falls below the 40/50 cm depth threshold or minimum organic matter content to be classed as peat. Such changes are not expected across large areas (they occur mainly from extraction and some lowland agricultural ploughing), and are usually permanent. Therefore, it is likely to be acceptable to treat the peat class as fixed on a decadal basis.
2. Peat growth – could occur through the very slow conversion of degraded shallow peat back to deeper peat - unlikely to see significant movement across this threshold on a decadal timescale.
3. An attempt could be made to split upland (blanket bog and raised bogs) from lowland (raised bogs) but it is unclear if the available data support this, and in practice the two bog types function similarly in many respects. Furthermore, although the split might work well for England, it is less helpful for Scotland, Wales or Ireland, where rainfall and slope are more important determinants.[140]
4. 'Woodland' on fens, and commercial conifer plantations in the uplands, could be assigned to 'broadleaf' and 'conifer' as in LCM
5. Not all managements are relevant to all peat/land-use types – to simplify/guide the classification, it would be better to assign a set of feasible management options to each peat/land-use class in a matrix. In practice, for the Peatland Code conditions, we merge the "Managed by Burning" and "Grazed" sub-classes into *Modified*, and we add a *Near Natural* sub class. Research work is ongoing to agree simple sub-classifications which can be remote-monitored.
6. Grazed and grassland categories could be reported together under the Kyoto Protocol (KP). Nutrient-enrichment would be difficult to quantify and is not required under UNFCCC/KP so unlikely to be done at national scale. Most of the other categories (except cropland and forestry) currently fall under the catch-all Grassland IPCC category, so getting this right (for the UK) by applying adequate sub categories is important. Ideally, semi-natural bogs and fens should be moved to a wetlands category.

From the land use classes and the management condition, the key characteristics of the peatland (e.g. whether it is drained/undrained, what provisioning services are obtained (e.g. food, fibre) can be determined. These characteristics can then lead to assumptions about the values of flow of ecosystem services from the peatland.

4.7 Peatland Ecosystem Services

The key way that the UK's peatland natural capital account will be populated with monetary value data is by valuing the annual flows, and capitalized flows over time, of the key ecosystem services (ES) it produces.

There is a wide range of ES from peatland – for a detailed discussion see JNCC 2013. For the purposes of UK natural capital accounts, the most important ES from peatland are judged to be:

- Food (grazing animals on moorland; intensive farming on lowland)
- Fibre (peat extraction, wool, timber)
- Water qualiity regulation

[140] Lowland raised bogs are similar in biodiversity and carbon terms to upland bogs, but have less impact on drinking water quality and flood management than the extensive upland bogs. If lowlands and uplands are to be split, it would be better to do this using the NE 'moorland line' than by altitude; for example, the Flow Country blanket bog is low altitude blanket bog.

- Climate regulation – greenhouse gas flux
- Flood management and water flow regulation
- Recreation
- Biodiversity

Climate regulation, water quality regulation, water quantity regulation, recreation and biodiversity are services which can be provided sustainably. Fibre (peat extraction and probably timber production) and some forms of Food production (especially those requiring agricultural drainage, fertilisation and tillage) can cause peat condition deterioration and peat loss. The following sub-sections consider each of these ecosystem services in turn.

Quantification and economic valuation of ecosystem services is critically dependent on the quality of underpinning science. Recent analysis by Evans *et al.,* (2014b) of blanket bogs derived quantitative 'pressure-response functions' linking anthropogenic pressures (drainage, burning, sulphur and nitrogen deposition) with ecosystem functions underpinning key climate, water quality and flood regulating services. This work was undertaken to try and refine the scientific basis for the analysis, and improve on the wetland valuations that UKNEA applied to peatlands. The analysis highlighted the effects of multiple anthropogenic pressures on different ecosystem functions, and suggested that condition measures such as the presence/absence of key plant functional types might act as an integrated measure of these impacts, and their influence on ecosystem service flows.

Whilst the analysis highlighted the need for holistic, inter-disciplinary approaches and better scientific data on the underpinning ecosystem functions, a substantial amount of peatland science is nevertheless understood sufficiently to make analysis of key ES in the peatland account feasible.

4.7.1 Food

Different agricultural practices use upland and lowland peatlands in the UK to produce food. In the uplands, the main system is grazing of livestock, particularly sheep, (a few cattle), and deer. In the UKNEA this ES is defined as part of the services from Mountain, Moor and Heath (MMH). However, within this, wet peatland areas are likely to be less suitable/productive for high density grazing. The market profitability of extensive upland grazing is often low or even negative when subsidies are factored out[141].

Lowland (crop) agriculture on peat soils requires deep drainage and therefore leads to large carbon emissions. However, the use of drained peat as a growing medium is highly productive in agricultural terms. Agriculture net margins for intensive arable production on Fenland (drained lowland peat) are estimated at about £480/ha in 2012 prices[142]. That study focused on an area of 20,500 ha of Fenland which could be restored to healthy peatlands in order to reduce carbon emissions. This area is 0.4% of the UK's tillage area (of 5.3 million ha) and less than 0.2% of lowland crop area, but produces about 0.6% the value of total crop production.

Food is also produced from recreational shooting activities in MMH areas, including peatland habitats. However, this is regarded as primarily a cultural service, with a relatively small amount of food being produced in national accounting terms. It therefore proposed that the production of game from shooting for food can be excluded from the UK's natural capital accounts.

[141] Although the sporting values of deer and grouse shooting can be high.
[142] Graves A.R. and Morris J. (2013). Restoration of Fenland Peatland under Climate Change. http://www.theccc.org.uk/wp-content/uploads/2013/07/Report-for-ASC-project_FINAL-9-July.pdf.

4.7.2 Peat (Extraction)

Peat extraction still continues in the UK, for horticultural use. The peat extraction industry classifies peat as a slowly-renewable fuel, and argues that its use should be considered sustainable; however, the IPCC recommended that peat needs to be accounted as a fossil fuel because of its GHG emissions and because it is so slow to accumulate[143] (After millions of years, peat becomes lignite coal.) In terms of the UK accounts, peat extraction should probably be classified as Extractive.

Background work by the project team for DECC[144] suggests around 7500 hectares of peat are presently subject to extraction in the UK; most of this is from lowland raised bogs. The Horticultural Development Company (HDC) records some 0.8 million cubic metres of peat extracted for horticultural use in the UK in 2012[145]. (Most of the UK's 2.2m horticultural peat consumption is imported from Ireland.) However, there are long term policy commitments to phase out peat production for this purpose, and horticultural peat use is decreasing year on year.

This data is converted to CO2 emissions for use in the LULUCF GHG inventory as set out in section 5 of the report footnoted[146]. The inventory does not use the HDC peat sales data collected from the inventory, but the reported sales of extracted peat for England and Scotland and estimated volumes/areas for NI.[147] Peat extraction no longer takes place in Wales, although there is a bog which straddles the border; the former Welsh extraction sites are being restored.

4.7.3 Wool

Wool production from sheep grazing on peatland is a small part of wool production from the mountain, moor and heath (MMH) UKNEA category, and hard to differentiate from it. At present, wool production has low economic value and low profitability. Wool production from peatland therefore need not be included in the peatland account, but would be captured in any account covering MMH more generally.

4.7.4 Timber

Some forest crops are grown on peatland in the UK, although there are policy guidelines now in place to discourage new afforestation on deep peat, and to restrict re-planting on deep peat. Afforestation, with its ploughing, ditching, intensive tree cropping, and (sometimes) fertilisation of peat, reduces the ability of peatland to provide (other, i.e. non-timber) ecosystem services, and can cause ecosystem losses[148]. Timber provision is a valued product (and is quantified in UKNEA); however timber grown on peatland tends to be less productive and less valuable than timber grown on other soils[149]. Sitka spruce is the commercial tree usually planted on peatland.

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[143] http://www.iea.org/media/workshops/2007/IPCC.pdf

[144] Evans et al 2014

[145] http://www.hdc.org.uk/sites/default/files/research_papers/CP%20100_Report_Annual_July_2013.pdf suggests 0.36M m3 from England, 0.26 from Scotland and 0.21 from Northern Ireland; concurs broadly with UK government data suggesting 0.422 from England and 0.146 from Scotland; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/285128/Mineral_extraction_in_Great_Britain_2012_-_Business_Monitor_PA1007.pdf

[146] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17144&FromSearch=Y&Publisher=1&SearchText=sp1105&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

[147] An alternative method would be to use the hectares figures and multiply by the EF developed by this project (WP1), i.e. 237ha multiplied by 23.84 = 5650 tonnes CO2eq.

[148] Ploughing, ditching and fertilising makes peat more suitable as a tree-growing-medium, but degrades the peat, releases the carbon, changes the peat bio-chemical and physical properties, and changes the water quality and hydrologic response of the water flowing down the ditches and into the rivers.

[149] The old adage was that 'black peat' will not grow profitable trees; (eg. Gilchrist 1876). This is partly because trees grown in peat show stunted growth and variety in growth-rings (which cause problems with twisting, splitting, and processing) and partly because even where peat has been deep-drained and double-ploughed, timber is difficult to extract from peatland – wind-blow can affect large areas, and extraction costs are high - machinery gets bogged down, and floating roads/bridges may be required, eg http://www.forestry.gov.uk/pdf/TimberTransportToolkitRoadDesignAnnex1.pdf/$FILE/TimberTransportToolkitRoadDesignAnnex1.pdf.

It should be noted that the volume and value of the stock and flow (annual harvest) of timber in the UK is being analysed in the draft UK woodland account (eftec, in prep). This does not distinguish timber produced on peatland, and the underlying soil is not regarded as a significant driver of timber production compared to other factors, such as tree species (deciduous/conifer).

4.7.5 Water quality regulation

The ES from peatlands in regulating the **quality** of water is a potentially important one. In most respects, water from peatlands that are in good condition is of a high quality, with very low levels of agricultural pollutants, pathogens and pesticides. These attributes make peat runoff desirable as a raw water source, either in isolation or as a source of 'clean' water with which to dilute more polluted water from other sources. However, peatlands naturally produce runoff which contains dissolved organic matter, which is associated with water colour and can increase treatment costs. Whilst all peatlands generate some dissolved and particulate organic matter, there is good evidence that peatlands that are drained and/or managed in some way export peatier water, resulting in increased costs of treating the water resources affected so as to be suitable for public supply. Peatlands in better condition produce less peaty water. Improving the condition of peatlands is expected to improve water quality[150].

Measuring the physical flow of this service is challenging. To measure the quality of water accurately would require a catchment by catchment assessment of water quality, and the presence/absence of drains, in order to value the additional costs resulting from treating the additional dissolved and particulate organic matter exported from degraded peatlands. This would appear as a negative (cost) item in the national peatland accounts. If peatland condition is improved, the benefit of this for water quality regulation would be expected to be reflected in a reduction in the size of this negative value.

The value of this negative impact of peatland degradation on water resources is potentially significant. However, these values are very context-specific (they will vary depending on the capacity and remaining lifetime of existing treatment infrastructure) and are hard to calculate from publicly available data.

Catchment specific data on the costs of treating water for public supply is considered to be commercially sensitive for the water companies in England and Wales, and therefore not generally in the public domain. The limited data that are available include:

- Water companies in England and Scotland have begun restoring their water catchments in order to improve water quality[151]. This is partly because of increasing water coloration from degraded peatland and the related treatment costs, and partly because of tighter regulations on water treatment and concerns over treatment methods[152].
- Estimates for two water companies in the North of England that an increase in water colour of one Hazen[153] per ML per day of water treated will result in an increase in treatment costs of between 10p and 20p. This is based on chemical costs of coagulants, and does not include costs of increased energy use, manpower or sludge removal. The energy costs of water treatment energy in particular can be significant. Where the capacity of water treatment facilities is

[150] which is why most UK water companies are presently restoring peatland catchments.

[151] Although lowland agricultural pesticides are usually the main concern, South West Water, Yorkshire Water, United Utilities and Scottish Water are all also involved in upland peatland restoration in order to improve their raw water source. For example, see *SCaMP corporate.unitedutilities.com/***scamp-monitoring***-reports.aspx. This evidence suggests that restoring peatland is cheaper than building new water treatment works.*

[152] trihalomethanes result from the reaction of chlorine with organic matter in the water being treated, they may have health implications.

[153] Discoloration of water is measured in Hazen units (HU).

exceeded, new technologies are required. For example, the cost of adding magnetic ion-exchange to a conventional 10 ML per day treatment works, where other treatment options are insufficient is estimated at £5-7m.

- CREW[154] identifies the following data on the value of this ES:
  - The Water Industry Commission for Scotland states that £60m of the £125m total operating costs, and £143m of the £250m total capital costs for Scottish Water[155] in 2007 – 8 water were for water treatment costs. Scottish Water has estimated that in a large drinking water catchment, implementing sustainable land management measures could save upwards of £10m over 25 years. Implementation of such measures to protect drinking water sources can reduce operational expenditure due to lower levels of treatment being required and can save capital expenditure when additional treatment steps are avoided.
- CREW also report that it is widely recognised that monitoring of alternatives to intensive water treatment is needed to understand the benefits that accrue from these, and to identify whether cost savings are being made.

Water regulating services from peatland are complex and require further research on the levels of ecosystem services and the values of the benefits that result.

4.7.6 Climate Regulation – greenhouse gas flux

In the context of UK and global carbon budgets, peatlands store a significant amount of carbon. This is an important 'stock' value for UK natural capital accounts, but the size of this stock cannot be accurately measured or valued. This mirrors global conclusions under the IPCC[156] that changes in the stock of peat are difficult to measure accurately as the basis for GHG accounting.

The ES related to this stock is the flow, the net flux of carbon to or from the peatland (i.e. carbon emissions or carbon sequestration). Because most peatlands in the UK are emitting greenhouse gases, the value of the ecosystem flow would be accounted as negative. Improvements in peatland management which resulted in fewer emissions would be reflected in the account as a reduction in emissions compared to the previous accounting period. The ecosystem flow would have a smaller negative value compared to the previous accounting period, meaning the value of the account would have increased.

Releases of carbon from peat soils globally are a major contributor to Greenhouse Gas emissions[157]. The size and direction (in or out) of flows of carbon from peatland are dependent on peatland condition. When peatlands are wet, carbon is accumulated because rates of plant growth exceed the slow rate of anaerobic decay, leading to long-term peat accumulation. When peatlands are dry, this peat accumulation process can decrease or cease, in addition to which the stored peat can oxidise and the carbon can be released to the atmosphere as CO_2. When peatlands are drained, some of the stored carbon can also flow out, via the drains, as peaty water. Most of the peaty water soon turns into CO_2[158]. Decreased emissions of methane (a more powerful greenhouse gas) from dry versus wet peat can have strong counter-effects, although the net effect of drainage is usually an increase

[154] http://www.crew.ac.uk/sites/www.crew.ac.uk/files/publications/CREW_%20Sustainable%20Land%20Management.pdf
[155] It should be noted that approximately 50% of areas in Scotland are supplied from private water supplies, not Scottish Water.
[156] Chris Evans pers com, May 2014; IPCC Wetland Supplement - downloadable from: http://www.ipcc-nggip.iges.or.jp/home/wetlands.html ~ implicit in the methods applied in Chapters 2 and 3 (for peatlands/organic soils) is that a flux-based approach was used.
[157] Birnie, R.V. and Smyth, M.A. (2013) *Case Study on developing the market for carbon storage and sequestration by peatlands.* Crichton Carbon Centre.
[158] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=2&ProjectID=17326

in overall greenhouse gas emissions in the short term[159], as indicated in the Peatland Code and illustrated in Table 4.4.

The focus of carbon ES analysis for peatland should therefore be on the annual fluxes (i.e. flows) in carbon. Measurement of these flows is easier than measurement of stocks, and provides direct quantification for the emissions or removals of each GHG, i.e. the ecosystem service. Different management practices for peatland have different implications for greenhouse gas emissions. Estimations have been developed for the level of greenhouse gas emissions per ha of peatland under different forms of management, as for example the metrics work done in Work Package 1 of this contract, pasted below. As more research is undertaken, these estimates will improve.[160]

Table 4.4 Emissions Factors for peatland condition (see Section 1.3.4). Emission Factors were developed using data from published sources ($tCO_2eq/ha/yr$) using IPCC default values for DOC values and relevant literature on peatland erosion for POC.

Peatland Code Condition Category	Descriptive Statistic	CH_4	CO_2	N_2O	DOC	POC	Emission Factor
Pristine	-	-	-	-	-	-	**Unknown**
Near Natural	Mean (±StE)	3.2(1.2)	-3.0(0.7)	0.00(0.0)	0.88[161]	0	**1.08**
	Median	1.5	-2.3	0.0			
Modified	Mean (±StE)	1.0(0.6)	-0.1(2.3)	0.5(0.3)	1.14[162]	0	**2.54**
	Median	0.2	0.1	0.5			
Drained	Mean (±StE)	2.0(0.8)	1.4(1.8)	0.00(0.00)	1.14[163]	0	**4.54**
	Median	1.0	-0.9	0.0			
Actively Eroding	Mean (±StE)	0.8(0.4)	2.6(2.0)	0.0(0.0)	1.14[164]	19.3 (average of 14.67[165] and 23.94[166])	**23.84**
	Median	0.1	0.4	0.0			

[159] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=15992&FromSearch=Y&Publisher=1&SearchText=sp0574&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

[160] In this draft, the emissions factor for Near Natural bogs is higher than expected, which is probably because this data came from small studies of accessible sites, rather than being done in long-term multi-EF programmes at more natural, remote sites. Future data from the Flow Country should help.

[161] Calculated as the mean value of reported values in UK studies given in Table 2A.2 of the 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Supplement) http://www.ipcc-nggip.iges.or.jp/home/wetlands.html

[162] IPCC Tier 1 default value for drained peatland (best estimate for modified condition)

[163] IPCC Tier 1 default value

[164] IPCC Tier 1 default value for drained peatland (best estimated for actively eroding condition)

[165] Estimated from UK blanket bogs (in Goulsbra, C., Evans, M. & Allott, T. (2013) Towards the estimation of CO_2 emissions associated with POC fluxes from drained and eroding peatlands. In: Emissions of greenhouse gases associated with peatland drainage waters. Report to Defra under project SP1205: Greenhouse gas emissions associated with non-gaseous losses of carbon from peatlands – fate of particulate and dissolved carbon. Report to the Department of Environment, Food and Rural Affairs, UK)

[166] Value from Birnie and Smyth (2013) unpublished, but recalculated to reflect that 70% of POC derived carbon assumed to be reaching the atmosphere with remaining 30% assumed redeposited (Chris Evans *pers. comm*).

Estimations have also been developed for the level of greenhouse gas emissions per ha of peatland under different forms of agricultural management (arable, grazing, forestry, etc)[167]. Using these estimates, it is easy to estimate changes in GHG emissions as a result of changed management, including restoration; see for example Table 4.5 which outlines expected greenhouse gas emission savings as a result of changing management of bogs.

Table 4.5 Table (see Section 1.3.4) showing changes in greenhouse gas emissions according to change in peatland condition. Net effect on emissions resulting from restoration and changing Condition Categories were calculated using the Emission Factors given in Table 4.4.

Condition Category Change	Net Effect ($t\ CO_2$ eq ha/yr)
Restoring from Modified to Near Natural	Saves 1.46
Restoring from Drained to Near Natural	Saves 3.46
Restoring from Drained to Modified	Saves 2.00
Restoring Actively Eroding to Modified	Saves 21.30
Restoring Actively Eroding to Drained	Saves 19.3
Allowing Drained to develop into Actively Eroding	Loses 19.3

Estimates of annual greenhouse gas emissions vary, because both the maps and the methods used are still developing. For example, it was estimated that England's peatlands are responsible for about 3 million tonnes of carbon dioxide equivalent (CO_2e) emissions per year (Natural England, 2010). Rough estimates in Scotland suggested a wide range of net emissions (-3.9 – 5.12 million tonnes of carbon dioxide equivalent)[168] due to the uncertainty over the net emissions from the large area of forestry plantations on peat. Over 1 million ha of peatland in Scotland have been identified as in need of restoration, with emissions of CO_2e expected to be reduced by up to 9 t/ha/yr for the most degraded sites[169]. Yet draft work by this research team for DECC[170] is highlighting the uncertainties, and suggesting that the UK figures could be around 21 Mt CO2-eq emissions in 1990, with a reduction in annual emissions of 0.52 Mt since then, much of which is a result of agri-environment policies (destocking). More research work, for example to compare Land Cover Mapping with on-the-ground signs of erosion, will help improve the figures. It will also be helpful if the approaches used for developing the UK Peatland Code (this project), the UK national ecosystem accounts, and the UK LULUCF inventory for wetlands are all comparable.

The valuation of a stock for the accounts is based on the capitalized value of ecosystem services flows – which includes the profile of flows over time; either constant or non linear (for peatlands, a non-linear profile could address expectations of future erosion). It could be argued that the current assessment of the value of greenhouse gas emissions from peatlands could be capitalized, giving the stock a negative value because the net flux is one of present and/or expected greenhouse gas emissions. However, if the valuation of capital is based on productive *potential* of the stock (i.e. avoided emissions), then peatlands have the potential to provide net sequestration of carbon, meaning that the capital stock should be valued at zero or a small value reflecting the capitalized

[167] Evans et al 2014; in preparation for DECC; and a variety of preparatory work by Artz (for CxC) and Smyth and Birnie (for NE); see also work package 1 of this project.
[168] http://www.climatexchange.org.uk/index.php/download_file/162/194/
[169] http://www.climatexchange.org.uk/files/1913/7339/0087/Research_summary_Potential_Abatement_from_Peatland_Restoration.pdf
[170] https://online.contractsfinder.businesslink.gov.uk/Common/View%20Notice.aspx?site=1000&lang=en&NoticeId=1501372 will develop the methodology for reporting on peatland drainage and rewetting in the LULUCF inventory, and is compiling some of the required information on area and quality of peat, as well as the climate regulation ecosystem service.

value of potential sequestration. This data would thus give a picture of peatlands as a natural capital resource with potential to yield a small greenhouse gas benefit to society, but which due to current management is yielding a significant annual loss in terms of the costs of greenhouse gas emissions.[171]

4.7.7 Flood management and water flow regulation

The effect of peatland condition on the **quantity** of water flow is complex. Although the condition of upland peatlands (and particularly their surface roughness) is known to determine the speed of surface runoff, the consequences of this for flooding at larger catchment scales are not well understood. Peatlands in different conditions (e.g. drained/undrained) can have different effects on the size and timing of water flows in catchments, and therefore this ES is very difficult to assess in national accounting terms. It is also a difficult ES to value, with values being very specific to the context in a catchment (e.g. level of existing flood risk management activity; nature and value of property at risk) and to the characteristics of particular rain events (e.g. flow attenuation in blanket bogs might help to reduce peak flows during short, intense rain events, but is unlikely to have an impact on sustained low-intensive events).

Lowland peatlands can also impact on flooding, through storage of water in floodplains. However, this is also a complex service and its value is again context specific.

Therefore, it is suggested that the ES from peatlands to regulate the quantity of water resources is not valued in the national accounts until further work has been done, for example by building flow attenuation and storage in peatlands into catchment-scale flood risk models.

4.7.8 Recreation

Case study evidence suggests that recreation is a very valuable ecosystem service in the UK, but it remains poorly quantified and valued in many ecosystem types. Methods to estimate systematic recreational values for UK ecosystems are being developed under the UK woodland natural capital account (eftec *et al.,* in prep). This is based on a trip generating function (TGF) drawn from work by the University of East Anglia for the UKNEA. This method shows promise for estimating the total number of recreational visits to different ecosystems in the UK.

However, this method needs further development in differentiating between, and allocating recreational visits and values to, ecosystem types. It may be problematic to analyse peatlands within it for two reasons. Firstly, recreational visitors are not always aware that they are visiting a peatland site. This is not a problem for data from the Monitor of Engagement with the Natural Environment (MENE), which is the basis for the UK woodland natural capital account recreational value in prep., as it geolocates visits which can then be related to habitat maps. However, it may be a problem for other data that could be used to supplement MENE data in the account. Secondly, it may not always be the case that changes to visitor behaviour and/or values can be linked to upland peatland condition.

For lowland sites (especially fens), the recreational value is often much clearer, quantifiable and relatable to condition - the sites are nature reserves, often support charismatic species, have known visitor numbers and in some cases charge admission. A comparison of (say) Wicken Fen with the surrounding arable fields would probably yield a very large recreational value.

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[171] Ideally, the accounting method should take into account a minimum stock requirement (i.e. thick enough peat), yet should also capture the fact that peatlands in good condition provide carbon sequestration services in perpetuity (for tens of thousands of years), whereas alternative means of sequestering carbon which might appear to have high productive potential (e.g. forestry plantations) have a much shorter lifecycle and carry costs in the regeneration phase (e.g. harvest and restocking).

For upland peatlands, data could be estimated as a proportion of the values for 'mountains'. This challenge for estimating peatland recreational values is shared with other ecosystems (e.g. relating to other open habitats, such as lowland heathland).

It is noted that cultural landscape elements are considered in the Peatland Code, but are known to be hard to capture. Rewetting is unlikely to cause many trade-offs due to reduced access[172], although there may be specific needs to realign footpaths, including parts of long distance routes such as the Pennine Way.

4.7.9 Biodiversity and Other Ecosystem Services

The biodiversity value of peatlands is highly correlated with peat surface wetness, and therefore whether significant carbon emissions are occurring. Biodiversity may therefore be best treated as a characteristic of peatlands, a supporting service whose value is related to peatland condition. Also, as SEEA[173] suggests, a biodiversity index may be used to reflect changes in its value. An index could be based on the species listed in the existing NVC and Site Monitoring schemes developed by NE, SNH etc. However, in the first instance, a fairly simple account of peatland biodiversity could be developed based on Peatland Condition, involving a small number of indicators, for example:

- An obvious indicator of peatland condition is predominance of *Sphagnum* in the moss layer, with higher cover being beneficial for both biodiversity and carbon. This is correlated with the value of peatlands' ecosystem services. A lack of *Sphagnum* mosses suggests a damaged and declining ecosystem: the peatland will be losing carbon, causing water quality problems, and supporting less biodiversity.
- Bare peat is a (negative) indicator of both biodiversity-loss and carbon loss, it too could be included in the account.
- Habitat quality can be indicated by surface roughness (hummocks of moss) and by species abundance and diversity; for example wet peatlands may have abundant invertebrates such as craneflies, important food species for peatland birds. However, selecting the most appropriate data may be an issue here.

4.7.10 Discussion

The previous sections and Table 4.6 indicate that many of the key services from peatland should have a place in the UK accounts, but are un-valued at present. The services which can be readily entered into the accounts are carbon fluxes (a proxy for climate regulation); food (which depending on the crop could have adverse implications for the value of peat); and peat extraction, which is extractive, so not properly a service. Given the sequestration potential described elsewhere in this report and the comparatively high commodity [agriculture, food] prices, under a Payments for Ecosystems Services perspective, peatland will be undervalued until biodiversity, water quality and flood management values can be quantified.[174]

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[172] Birnie and Smyth 2013 (NE0136) found that even in cultural landscapes such as the Bronte Country moorland, the traditional paths tended to be on the harder ground, or along breaks-of-slope, not through the bogs. In Northern Ireland's Peat Park, parts of re-wetted bogs are used for education (displays of traditional peat cutting) and bog snorkelling. At extraction sites, restoration is often associated with boardwalks and viewing platforms to encourage visitors to see cranes, bitterns, marsh harriers and starling roosts.

[173] https://unstats.un.org/unsd/envaccounting/seea.asp

[174] There may also be a need to value the use of peat as a soil beneath arable/horticultural crops; or at least to investigate how best to account for this value. Long term drainage and use of peat as an agricultural soil can lead to deep wasting, subsidence of the peatland and eventual loss of the land to farming. The climate-impact of this would be picked up by the GHG account, but the loss of a farming resource might need to be valued separately.

Table 4.6 Summary of Ecosystem Services from peatland, presented after Defra SP0572 "Ecosystem Services of Peat", UK NEA (2011), and JNCC (2013), with notes on how they can be framed in the UK National Accounts.

Ecosystem Service type	Ecosystem Service delivered by peatland	Value suitable for the UK National Accounts?
Provisioning *Likely valuation method: market prices*	Food, raw materials, fibre	Food grown on peatland includes intensive crop and horticultural production from drained lowland peatlands (high value) and extensive livestock grazing on upland peatlands. Use market values; location specific; and note that market values also include value added through other forms of capital (e.g. human, manufactured)
	"Renewable" fuel/growing medium[175]	Peat extraction is probably not 'renewable' in UK, as peat re-growth is slow. An estimated 0.8 million cubic metres of peat in the UK is extracted each year for horticultural use. This results in carbon emissions and loss of the peat resource. Long term policy commitments are for it to be phased out.
	Drinking water supply	70% of the UK's drinking water supply comes from peaty catchments[176]. Peatland's contribution is in regulating its quality, see below.
Regulating *Likely valuation method: market prices or avoided losses*	Water quality	Water quality regulation has a substantial value, and water companies place a higher value on raw water with minimal organic carbon than on turbid, peaty water coming from gullied or drained peatlands. Exclude values from the accounts at first because this service cannot yet be accurately valued, however, valuation may be feasible with further research. Calculate avoided losses.
	Climate - Greenhouse Gas flux; GHG flux; stores of organic carbon	Quantify and monitor GHG fluxes (i.e. the ecosystem flow). Stock of carbon is less important in accounts, because deep-buried water-logged peat does not affect climate, and also because the size and value of the substantial stock of carbon stored in peatlands cannot be accurately measured. Use existing (Peatland Code, IPCC) metrics and market values.
	Flood management	Exclude values from the accounts at first; plan to calculate avoided losses soon
Cultural *Likely valuation method – willingness to pay, market prices*	Archaeology, palaeoecology	May be priceless? Exclude values from the accounts at first
	Landscape and recreation (appreciation, leisure and sport)	Recreation, which is known to be significant from case studies, needs to be valued systematically as part of analysis of recreational values of all UK habitats with the national natural capital accounts. Include visitor numbers (and ticket prices) to wetland nature reserves
Supporting *Likely valuation method – indirect or priceless –and beware double-counting*	Biodiversity	Biodiversity is difficult to value. Good peatland habitat is internationally rare, so is high value. Some biodiversity benefits (bitterns in Fens, starling roosts in Somerset) may provide recreational value. May need to treat biodiversity as a characteristic of peatland and relate to condition, in which case could value as stock and flow. Exclude values from the account at first; no suitable valuation data.
	Soil formation	Peatland soils are used for farming, see above.

[175]The peat extraction industry classifies peat as a slow-renewable fuel; however, the IPCC recommended that peat needs to be accounted as a fossil fuel because of its coal-like GHG emissions. http://www.iea.org/media/workshops/2007/IPCC.pdf After millions of years, peat becomes lignite coal.
[176] *www.iucn-**uk**-peatlandprogramme.org*

4.8 The Approach to a Peatland Account

The approach to developing a peatland account can take a number of approaches: bottom-up, top-down, or spatially disaggregated.

Spatially disaggregated accounts enable identification of ecosystem services flows and values based on location specific factors (e.g. the condition of peatlands). However, they often take greater effort, requiring detailed mapping of the spatial extent of the amount of the asset in different conditions (e.g. eroded, healthy), and data to differentiate the flows of services from these areas. Such mapping of peatlands is under development, so spatially disaggregated accounts are a feasible option. The additional work to develop spatially disaggregated accounts will be worthwhile, because flood risk, water supply and recreation would all benefit from a disaggregated approach. Whether the additional work to develop spatially disaggregated accounts is worthwhile depends on the extent to which the major values of ecosystem services from peatland vary by spatial factors that can be better reflected in them.

Considering this issue for the key services identified above from peatland:

- **Carbon and Climate** – this varies significantly according to the condition of the peatland, ranging between significant negative flows to small positive flows. However, the physical flow and value are the same for a peatland in a certain condition irrelevant of location, so spatial disaggregation does not add anything to an account that distinguishes peatlands in different conditions.
- **Flood management and water flow regulation** – this ranges between positive and negative flows, depending on peatland condition. The value of this service is known to be significant, and to vary significantly by location. However, the exact range of values depending on different peatland condition is not known.
- **Water quality regulation** – this also ranges between positive and negative flows, depending on peatland condition. The value of this service is known to be significant, and to vary significantly by location. However, the exact range of values depending on different peatland condition is not known.
- **Food** – Varies with location. Food from blanket bog, mountain and moorland peatland has a comparatively low value to society, but food grown on the deep peats of East Anglia, the Fens and Somerset has a very high value, especially the areas used for arable and horticulture.
- **Fibre** (peat extraction, wool, timber) - Varies with peatland condition but is not considered of high value to society.
- **Recreation** – High value, but the distribution of the service for peatlands is unclear, and likely correlated with other factors (visitor facilities, surrounding ecosystems). Modelling of this service for the peatland ecosystem account will benefit from a spatially disaggregated approach. This will provide more accurate data, and visitor numbers are known to be correlated to surrounding human populations. However, exactly how values vary spatially is not fully understood.
- **Biodiversity** – Value is unclear, but likely significant, and varies significantly with peatland condition. Value can vary with spatial location (e.g. with certain locations being more valuable due to regional scarcity or their role in ecological networks), but this service is poorly quantified and valued, so spatial disaggregation is unlikely to make a practical difference to the account by 2020.

This list illustrates that most peatland services are known to vary significantly according to the condition of peatlands. For carbon, and potentially (at least qualitatively) water regulation, it is possible to link the value of services to data on peatland condition. However, only for water services is there a realistic prospect of varying the physical flows and values of a service based on spatial location. The practicality of such analysis needs further assessment to establish the feasibility of linking the role of peatlands to catchment dynamics and public water supplies. A similar observation applies to recreation, it is a service with a high value that is known to vary significantly by location. But the feasibility of analysing this needs to be established through the development of analysis of recreational services across ecosystem accounts, as described above.

Until the feasibility of establishing such relationships is established, there is not a strong case for developing a spatially disaggregated peatland account that allows calculation of spatially distinct values.

A more significant factor at present is the need for effort on identifying the extent (and to a lesser degree spatial location) of areas of peatland in different condition. This condition data is improving, and so it is anticipated that in the medium term (2-5 years) a spatially disaggregated peatland account would give a significantly more accurate measure of the physical flows and values of services from peatland. This means that a bottom-up construction of the account, based on areas of peatland in different condition, is the recommended route to developing the peatland account.

Over a similar periodicity (updating the account every 2-5 years) changes in peatland condition would be better reflected in a spatially disaggregated account.

4.9 Research Needs and Conclusions

This Section scopes key issues in developing a UK peatland natural capital account. The main conclusions for the boundaries of the account are that:

- Identification of the extent of peatland is not accurate through the 2007 land cover map. Therefore, other data (from ongoing country peatland mapping work) need to be used and overlaid with the LCM to ensure consistency with the wider UK natural capital accounts. This would require adjustment to other asset classes (e.g. woodlands, wetlands) to avoid double counting.
- The distinct ecosystem services from peatland mean that it is essential to treat it as a distinct asset within the accounts. Having a peatland asset class would bring together relevant data and assist with peatland management policies. However, an alternative approach is to include peatland as a subclass in other assets (e.g. woodlands, wetlands). The differences between these approaches are mainly presentational, as the same data will be needed in either approach.

In order to develop the UK peatland account, some key research needs are identified:

- Develop more accurate maps of the extent of deep peat (according to national definitions) across the UK. Work is underway to develop more accurate mapping (C. Evans pers com) and this should be supported, and where necessary extended, to ensure data that can support a natural capital account are produced in time for 2020.
- Integrate these peatland data with LCM 2007 (or whatever data sets are used for the overall extent of different asset classes in the UK accounts). This should determine differences between the detailed mapping of peatlands and its extent in the LCM2007, and then adjust other asset classes to correct for these differences.
- Develop data on condition of peatland assets, for example, by incorporating data from site condition monitoring and from peatland restoration schemes.

- Develop, using best available science, a matrix relating the different land use practices/ management practices on UK peatlands to peatland condition and therefore ES flows:

Suggested key indicators of the condition of peatland ecosystems are listed in Table 4.7.

Table 4.7 Possible ecosystem condition indicators for peatland

Indicator	Data source	Available now?
Presence of mossy hummocks, or Abundance of *Sphagnum* in the moss layer. This would provide GHG and water data; extending this to include Calluna (heather) and Molinia would provide additional biodiversity data	Use NVC data for listed sites. Aerial images of surface roughness and wetness. Link to carbon metrics[177] to create £ values	Yes for listed sites, and add in data from remote sensing of other sites as it becomes available. Is presently being trialled via air photo mapping work in Wales.
Area of bare ground	Use NVC data for listed sites. Link to carbon metrics to create £ values	Yes for listed sites, and add in data from remote sensing of other sites as it becomes available
Water colour from drainage ditches (Hazen values) higher values are correlated with higher water treatment costs.	Use data from EA, SEPA and water companies. Link to water company data to create £ values	EA and SEPA data only for a few locations. Plenty colour data from raw water intakes. CEH are doing some modelling work for SEPA to predict what the 'reference' level of DOC should be for a given site (given its peat area, altitude etc) in order to then assess whether DOC is higher than this expected reference due to management, so this might be a more robust/feasible approach, but would certainly require spatial disaggregation.
Area of peatland restored	Use data from IUCN. Could use restoration costs as £ value	Yes

The unit values (or their ranges) in this matrix can then be used to develop the ecosystem account (physical measurement of ES flows) and the monetary account (valuation of those flows). This should build on work already underway to develop 'pressure-response functions' relating pressures on peatlands to levels of ecosystem services (e.g. Evans *et al.,* 2014b). This link may be made via key indicators of peatland condition, such as presence of *Sphagnum* mosses. An example of such relationships is shown in the Table 4.8 below[178]:

[177] Suitable carbon metrics would include those published in Birnie and Smyth 2013, and developed in Work Package 1 of this contract.
[178] (from (Birnie, R.V. and Smyth, M.A. (2013) *Case Study on developing the market for carbon storage and sequestration by peatlands.* Crichton Carbon Centre. NE0136

Table 4.7 Example of links between peatland condition and ecosystem service

Peatland condition	Type of ecosystem service	Quality of ecosystem service	Flow of ecosystem service	Effect on climate
Healthy peatland	Carbon sequestration and storage	Very good	Improving	Beneficial
Grazed peatland	Carbon storage	Adequate	Steady or deteriorating	Variable
Burnt peatland	Carbon storage	Adequate	Steady or deteriorating	Variable
Degraded peatland	Carbon storage	Poor	Deteriorating	Damaging
Eroding peatland	Carbon storage	Very poor	Deteriorating	Damaging

4.10 Next Steps in Developing a Peatland Account

Suggested actions to develop the UK peatland account are as follows:

I. Boundaries and Mapping.

a) Decide if peatland is to be treated as an asset class with its own account or a sub-class within other accounts. This needs consideration of approach across UK natural capital assets, but the former is recommended as a more stable approach to classifying peatland assets.

b) Encourage and use data from national peatland mapping initiatives.

II. Condition and Ecosystem Services

While awaiting the mapping results from I:

a) Develop a matrix relating key land uses of peatland to the condition of upland and lowland peatland, giving rules allowing calculation of ecosystem services flows, and of allocation of land to appropriate sub-classes (e.g. afforested peatlands are assumed to be drained, therefore are net emitters of X soil carbon per year, and under LCM2007 will also be counted in the woodland natural capital asset account).

b) Develop flows and valuations for peatland services already available (e.g. for carbon, food and fibre).

c) Develop a more detailed modelling/valuation approach for peatlands' water regulation ES. This may need to be pursued in conjunction with water service operators and their regulators, and across multiple ecosystems (e.g. also looking at woodland). It may involve catchment-scale hydrological modelling and paired treatment/control data on DOC from comparable sites.

d) Develop understanding of recreational value from peatlands as part of development of a trip-generating function to measure the physical flows and values of recreational visits to all UK ecosystems for their respective accounts.

III. With the results from more detailed national mapping in I:

a) Relate this data to the data (expected to be the LCM2007) used to determine the extent of other assets in the UK natural capital accounts), concluding with an estimate of the extent of peatland assets.

b) Adjust the classification of other assets in the natural capital accounts (either by the removing peatland area being counted in a peatland account; or by introducing a peatland sub-class, depending on the approach taken).

c) Apply matrix of ES flows and values to data on extent and condition of peatland to estimate UK national ecosystem and natural capital account values.

d) Undertake a natural capital asset check of peatland to verify choice of ES to be included in the peatland account.

IV. Further work which will help populate the accounts:

a) More detailed spatially disaggregated analysis of water quality regulating services, with cooperation from water utilities and their regulators (OFWAT, EA) to establish an industry-wide approach to identifying the key factors that influence the physical flow and value of this service from peatland. This would need to relate peatland extent in a catchment, and its condition, to existing water supply infrastructure and its age/ condition (and hence running and renewal costs). The objective would be a more accurate measurement of the physical flow and value of this service in a manner that could be repeated over time (approx. every 5 years when the relevant data, including on peatland condition, could be updated). This modelling of water supplies via public utilities could be extended to private water supply sources. It is noted that such modelling is highly relevant to the accounts for other ecosystems that play a significant role in regulating catchments (e.g. woodland, wetlands, mountain moor and heath).

   While in the first instance the objectives of this work would relate to water quantity and quality for daily public supply, the same data could be expanded to analyse the role of peatlands in moderating extreme events – both flooding, and regulating flows during periods of water shortage. Analysis of the role of peatlands in flooding requires modelling of overall catchment hydrology, and needs to include all peatlands, as well as the current Pennines focus.

b) Survey work to establish the role of peatland features in attracting recreational visitors to locations with peatlands (even if they are not aware of this). This data would need to be structured in order to be aggregated using MENE data.

c) Using remote sensing, generate maps and data on drained and gripped peatland (including ditched-forestry on peatland). At present, neither the location of drained peat, nor the percentage of drained peat, is known, and this has a big effect on the calculations of greenhouse gas emissions and on biodiversity and water regulation impacts (some estimates suggest a range of 10-50% of Scottish blanket bogs are gripped); so this would help strengthen the present estimates.

d) Compare datasets of acid deposition with CEH's modelled water colour maps (designed to predict baseline DOC for anywhere in the UK uplands) and a catchment map of public water supply sources to build estimates of how the cost of cleaning up peaty water relate to peatland condition, and hence the value of that ecosystem service.

e) Investigate potential biodiversity metrics in more detail and consider potential for primary valuation work to value biodiversity. Both metrics and values would need to distinguish variations for peatlands in different condition. This could investigate the use of agri-environment scheme data to establish which of these influence peatland management, and how the actions take impact on the physical flows and values of ecosystem services from peatlands. Modelling could also potentially inform accounts for other ecosystems, obviously for agricultural land, but also mountain, moor and heath. There may be difficulty in distinguishing management measures for peatlands where agri-environment agreements are for whole farms, which may also make analysis on impacts on all ecosystems involved more practical.

Finally, we recommend that this work should be coordinated with ongoing national initiatives examining peatlands throughout the UK, and coordinated across all relevant accounting systems, so that similar approaches can be used by both greenhouse gas inventories and ecosystems accounts.

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5. Project Conclusions and Recommendations for Future Research

This project provides data, protocols and procedures to support the Peatland Code. The Peatland Code is a voluntary system, like the Woodland Carbon Code, which links peatland funders with peatland conservation, using peatland condition as a proxy for greenhouse gas emissions. This report shows that people restoring peatland in the UK are keen to engage with the Code, and welcome the development of metrics, protocols and best practice in peatland restoration.

5.1 Summaries (linked to Work Package Number)

5.1.1 UK Metric for Peatland Restoration (WP1):

- Provides robust Emissions Factors (GHG carbon dioxide equivalent) for 4 peatland condition categories definable in the field: *Near Natural*, *Modified*, *Drained*, and *Actively Eroding* (there are thought to be no pristine bogs in the UK).
- Expertly analyses and statistically checks those Emission Factors to remove outliers; and triple-checks for site vegetation and peatland condition characteristics to ensure that the Emission Factors do indeed reflect that category of peatland condition to the best of our current knowledge.
- Provides, designs and develops a Field Protocol, a short illustrated tick list to be used in the field for identifying those condition categories.
- Provides a method to quantify the emissions saved if the peatland was restored to a better condition, and how much extra GHG would be emitted if the peatland was to deteriorate into a poorer condition.
- By insisting that the classification and protocol must be acceptable to experts but usable by non-experts; and must have potential to be carried out quickly or by remote sensing, it maximises Peatland Code systems' user-friendliness to potential UK users.
- Collates and analyses the data for the Emissions Factors in a way which is consistent with international GHG accounting guidelines and can be used by the developing UK environmental accounts.
- By ensuring that the metrics would be suitable as a future Tier 2 Emission Factor for the UK, maximises Peatland Code underlying systems' usefulness to the UK.
- Field tests and refines the protocol with help from peat restoration projects throughout the UK, and incorporates their comments and recommendations.
- Enjoys buy-in from Peatland practitioners, who welcomed the metrics and protocol as a straightforward system suitable as a Tier 2 approach for the UK. Individual projects, especially those benefiting from detailed experiments, will of course continue to use more complex field protocols and flux data, which would effectively provide Tier 3 classifications and EFs for their specific sites.

5.1.2 Economic Assessment of the Peatland Code (WP2):

This work has created a spreadsheet to allow peatland restoration projects or potential funders to identify the costs and benefits of peatland restoration using the Peatland Code for any one project, and to compare projects.

- Creates a tool to allow Peatland restoration projects to identify financial costs and benefits of peatland restoration
- Includes over-writable check lists of estimated costs for each type of peatland restoration (eg. ditch blocking, gulley re-profiling), income foregone, and carbon benefits.
- Allows people to quickly identify which projects are economic at which carbon prices, and allows inputs to be changed (costs, timescales, monitoring systems) to help identify how to make other projects more economic.
- Is easy to use, because the tool is fully integrated with the field protocol.
- Provides detailed discussion on the carbon markets, comparison with the Woodland Carbon Code, and signposts for next steps.
- Identifies that at present carbon price is not sufficient to cover the cost of long term management (30 years plus) project of many peatlands and that there is a need for additional revenue from, for example, agri-environment schemes (see Figure 5.1 for illustration).
- At present carbon prices it would be most economical to restore gullied peatlands and some drained peatlands under the peatland code ie. where carbon benefits are greatest.

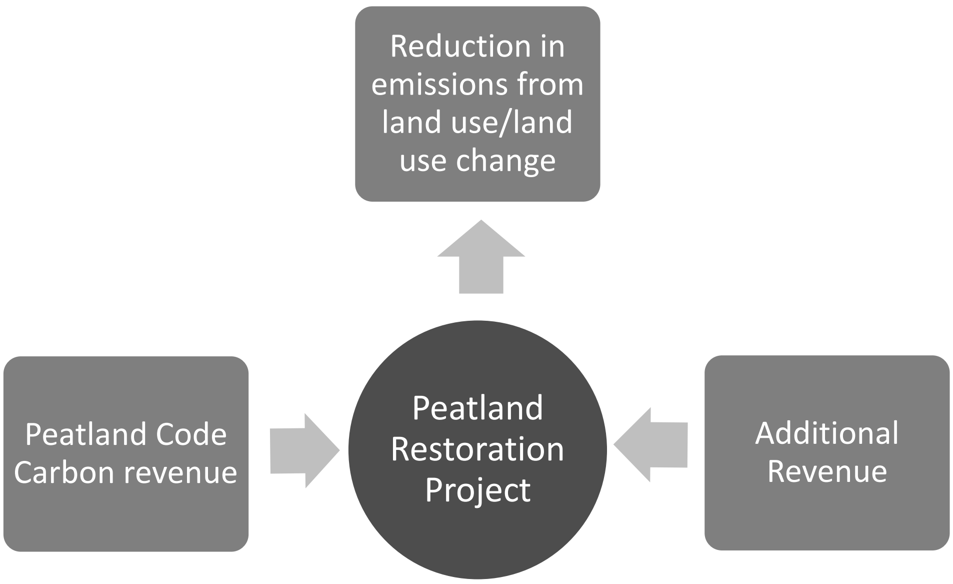


Figure 5.1 A schematic diagram showing the funds required to reduce greenhouse gas emission from peatlands

5.1.3 Potential for Biodiversity in the Peatland Code (WP4):

The work recognises that although it is difficult to put a monetary value on peatland biodiversity it is possible to conceptualise a biodiversity rating system, based upon the potential ways a peatland restoration project can enhance biodiversity.

- Recognises that it is not possible to put a monetary value on biodiversity of peatlands but also recognises that without some sort of valuation, peatlands will be undervalued, and improvements to biodiversity would be undervalued.
- Suggests a rating system to indicate improvements in peatland biodiversity based on peatland habitat condition, habitat connectivity and species groups.
- Recognises the importance of habitat functionality and local distinctiveness
- Recognises that good habitat quality, indicated by microtopography and valuing hummock dominated systems, positively correlates with good bog biodiversity, water quality and improved flood management.
- Recognises that this should in turn make for a potentially efficient monitoring system. For example, a soft, hummocky peatland provides good biodiversity, water quality and water flow management, whereas a hard, flat peatland provides poorer biodiversity, poorer water quality and flashier floods.
- Recommends future directions for development of a biodiversity metric.

5.1.4 Scoping the Natural Capital Accounts for Peatland (WP3):

This work sets out the framework for peatland accounting within the UK accounts.

- Provides a framework and suggested approaches for building the UK wetland accounts, using an ecosystem services approach (Table 5.1).
- Recognises that because biodiversity, water quality and flood reduction are not presently easy to value, the UK economy undervalues these ecosystem services, and hence undervalues peatland in good condition. Developing metrics is key to helping the UK properly value its ecosystems.
- Aligns the needs for a UK system with that of the international GHG accounting system.

Table 5.1 Sketch of potential structure for a peatland account (as in Section 4.3)

			Type of ecosystem		
			Peatlands		
			Flow (Annual, 2012)	Profile of Flows (‘20’ yrs)	
Provisioning	Food	Livestock grazing	£		
		Cropping/horticulture	£		
	Fibre	Wool	*minimal*	-	-
		Peat extraction	0.8 million cubic metres		
		Timber	*0 (already in woodland account)*		
Regulating	Greenhouse Gas Flux		*20 MtCO2 (use figures from DECC)*	*0.5 MtCO2 (20 yrs; 2012-2031)*	*MtCO2 (20 yrs; 2012-2031)*
	Water quality regulation		*Difficult to measure in physical and monetary terms, but may be possible to model change in DOC*	*Difficult to measure in physical and monetary terms*	
	Flood and flow management		*Difficult to measure in physical and monetary terms (HM Government, 2014)*	*Difficult to measure in physical and monetary terms, but may be possible to model changes as a result of peatland condition improvement*	
Cultural	Recreation				
Supporting	Biodiversity		*Difficult to measure in physical and monetary terms (HM Government, 2014)*	*Difficult to measure in physical and monetary terms … but could link to changes in peatland condition class*	

5.2 Project Summary and Conclusions

Peatland restoration provides multiple positive benefits to people and nature. Of these ecosystem services, carbon (i.e. greenhouse gas emissions) is the first to be quantified.

- This project provides Emission Factors and Emissions Savings Factors for peatland restoration, and indicates an outline approach to the potential first-step valuation of other ecosystem services such as water quality, flooding and biodiversity. However, there is still no obvious way to measure the cultural services provided by peatland.
- For most of the ecosystem services, the market is poorly developed and as a result there are few and limited buyers. There is a small voluntary market for carbon, but the carbon price is still too low to encourage meaningful peatland restoration.
- This project has demonstrated the support for the Peatland Code from peatland owners and managers.
- The prospect of a longer term funding source for peatland restoration and ongoing management, beyond the traditional timescales of European funded projects and agri-environment schemes, is particularly supported as this will ensure long term maintenance on peatland carbon stores and important habitats.
- However, the value of peatlands to the wider society, has to be promoted if investors are to fully engage with the Peatland Code and recognise the opportunities for meeting CSR objectives and improving environmental credentials.
- Currently, it is envisaged that Peatland Code projects will have to be paid for using multiple funds. i.e. possible funding under the Peatland Code alone is not sufficient in meeting all project costs. Agri-environment schemes will likely be a key source of additional funds, and therefore the potential of the Code will be constrained by the usual limitations of these schemes. In addition, it may make the Code more or less appealing in the different devolved administrations due to the variability in capital and management payments rates in their respective agri-environment schemes.
- Crucially this project creates a metric which can underlie the Peatland Code and be used for the UK Natural Capital accounts (peatland account), and the UK's international accounting system for greenhouse gases (Tier 2), key parts of which can be monitored remotely in the future. The Peatland Code therefore directly feeds into UK Natural Capital Accounts and ultimately International greenhouse gas accounting (Figure 5.2).

Figure 5.2 Schematic to indicate links between the Peatland Code metrics and other UK accounting systems

- Throughout this project habitat condition (as a proxy for ecosystem functionality) has been recognised as the basis for the provision for each of the key ecosystem services, and is identifiable using the Field Protocol. Although the field protocol and peatland condition criteria have been developed specifically for carbon these indicators are potentially transferable to other ecosystem services. This linkage may prove helpful in future efforts to quantify and value ecosystem services (Figure 5.3).

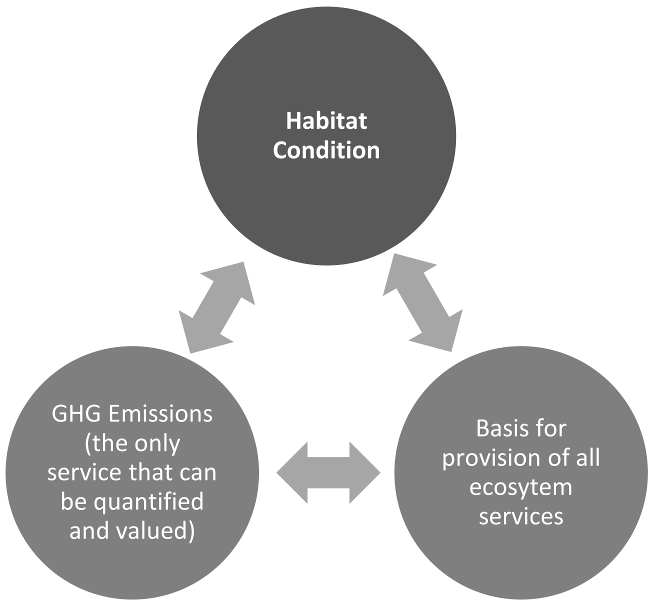


Figure 5.3 Schematic to show that habitat condition as a proxy for functionality underlies ecosystem services and that the Peatland Code metric is intrinsically linked to habitat function.

5.3 Key Messages for Supporting the Peatland Code

Creating markets and buyers for Ecosystem Services is a key component of sustainable natural resource management. We need to develop new markets and new mechanisms to bring the product to the market. The Peatland Code and this project provide the foundation and the framework for this, but there are still missing links which need to be addressed to support funding of peatland restoration in the UK.

1. Peatland restoration would become economic if there was a higher carbon price, and a market for carbon from land use and land use change in the UK (a positive outcome from the UN climate negotiations in Paris December 2015 would provide a step in this direction).
2. With a functioning carbon trading system in the UK, the Peatland Code could be the pilot for how to fund ecosystem restoration and nature conservation through carbon pricing. The Government has a potential role in creating a carbon market in the UK.
3. Without a functioning carbon market and a significant carbon price, the Peatland Code will need to focus on Corporate Social Responsibility and voluntary efforts to restore peatlands. This may result in restoration being prioritised towards well recognised

places such as sites owned/managed by conservation agencies/NGOs, and national parks.

4. Quantifying and demonstrating the positive correlations between carbon, biodiversity, water quality and water flow regulation should be possible. Further development of metrics and monitoring for biodiversity, water quality and flood management will help. An agreement of circumstances in which is it permissible to use peatland condition as a proxy for all the above could allow the Peatland Code methodology to be used for all of them.
5. Ideally, agri-environment policy should support and complement approaches to ecosystem restoration, such as the Peatland Code. For example, it would not be helpful if sites in receipt of Peatland Code funding became ineligible for CAP funding.

5.4 Recommendations for Specific Follow-up Actions

1. As soon as data become available the metric and field protocol developed here should be expanded to include restoration of afforested bogs.
2. To complement the launch of the Peatland Code, workshops will be required to demonstrate metrics and protocol.
3. The Peatland Code would benefit from more data on the risks and the immediacy of effect of peatland restoration by comparison to woodland creation.
4. A Proof of Concept of how to integrate the Peatland Code with current agri-environment schemes will be necessary in each of the devolved administrations to reflect variations in agri-environment schemes and payment rates.
5. Peatland restoration projects need to be monitored and a monitoring protocol will be required. The protocol developed here could be the foundation for this and would need further testing in conjunction with developments in remote sensing.

Annex 1 Field Protocol and Guidance

Peatland Code

Assessing the Condition of your Project Site

Guidance and Procedures

Emily Taylor
Mary-Ann Smyth
Dick Birnie

March 2015

1. Desk Based Assessment of Aerials

2. Field Survey

3. Confirmation of Site Condition(s)

tCO_2 eq/ha/yr

4. Calculating Emissions Savings

?

5. Further Information

1. Desk based assessment of aerials

Purpose

The purpose of the desk based assessment of aerial photography is to start to identify the condition(s) of the peatlands at a potential Project site. By assessing the site using aerial photography a site can be mapped into different units (Assessment Units): those which look to fit one of the four Condition Categories and those areas which are clearly not peatland and not eligible for the Peatland Code (for example rocky outcrops, water bodies etc.). This information forms the basis for the field survey as each individual Assessment Unit identified will be surveyed in the field to assess/confirm its condition.

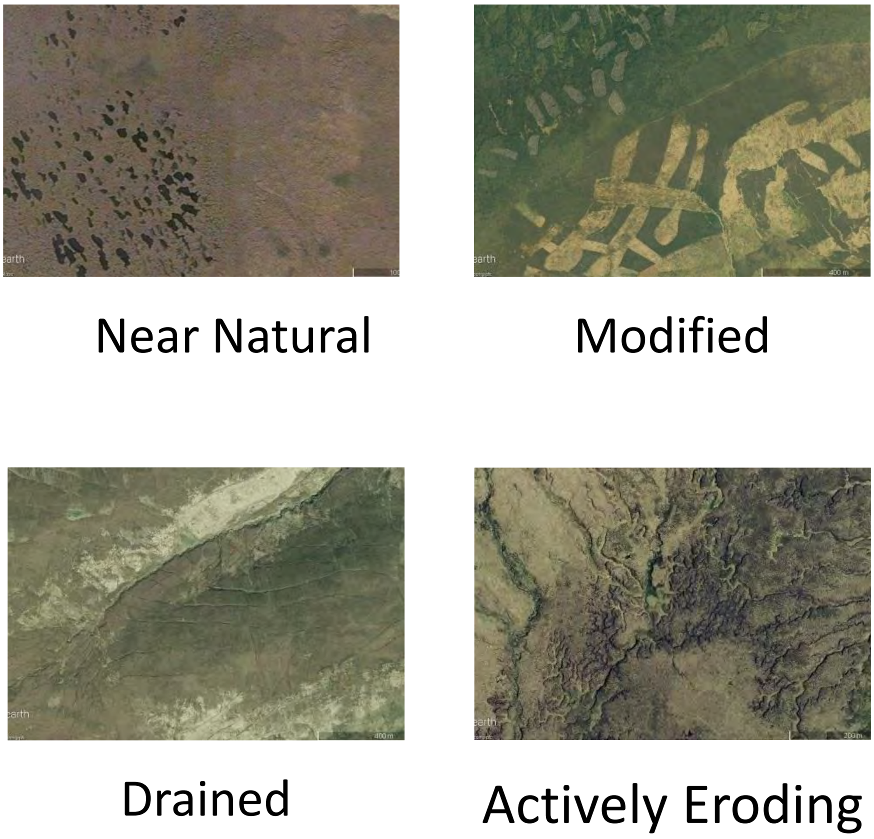


Figure 1. Example aerial images of peatlands in the four Condition Categories

Condition Category: Drained

Indicator: drains (not natural watercourses) present or re-vegetated hagg/gully system present within 30m

Some of the categories are easier to identify using aerial photography than others. Drains can show as obvious linear features, both in an apparently random arrangement and in a more uniform parallel layout. Drained areas are to be mapped as discrete Assessment Units, with the mapping unit measured as 30m out from the edge of the last drain (Figure 2). This gives the estimated area that has been drained, and subsequently the area that can be expected to be re-wetted following restoration.

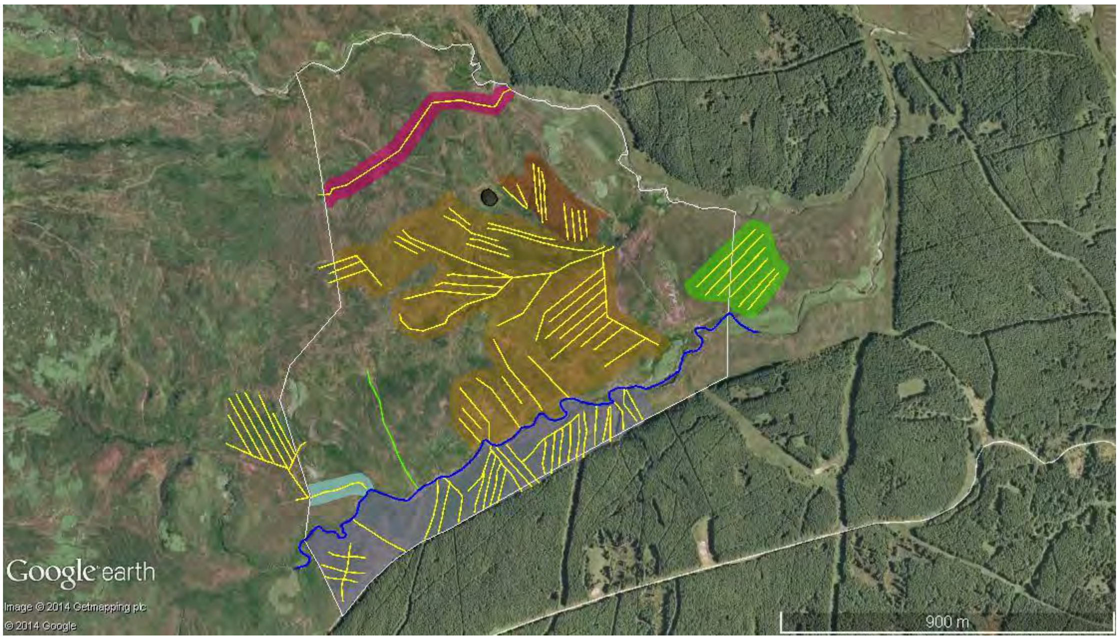


Figure 2. Example project site (boundary shown in white) mapped into drained areas. Drains are traced with yellow lines and each drained area is mapped as an Assessment Unit by extending 30m from the last drain. Each drained area becomes an Assessment Unit for the field survey.

Condition Category: Actively Eroding

Indicators: presence of actively eroding haggs/gullies with no or limited vegetation in gully bottoms and/or areas of extensive continuous bare peat

In severe cases where bare peat is extensive, actively eroding peat can be very obvious, appearing as dark broken edged areas on aerial photographs (Figure 1). Often a hagg and gully landscape is identifiable although there may not be bare peat visible. This could indicate limited active erosion or historical erosion (subsequently re-vegetated). These areas should be mapped as an Assessment Unit so the field survey can determine if the areas meet the criteria of the Actively Eroding category or the *Drained* category.

Condition Categories: Near Natural and Modified

Indicators: areas which appear to be peat but are not drained or actively eroding, obviously managed (eg. burn areas clearly visible, see Figure 1)

These categories are the hardest to distinguish from aerial photographs but are usually mapped as areas which do not fit the criteria for Drained or Actively Eroding Condition Categories. Usually some understanding of current and past management will help determine if the areas are likely to be Near Natural or Modified. Some features are very distinctive, such as burning, but it is generally assumed that these categories are best distinguished in the field. An example of how these areas would be mapped is shown in Figure 3 where Assessment Units (AU) 1, 3, 5 and 8 could only be assessed in the field to determine if they are Near Natural or Modified.

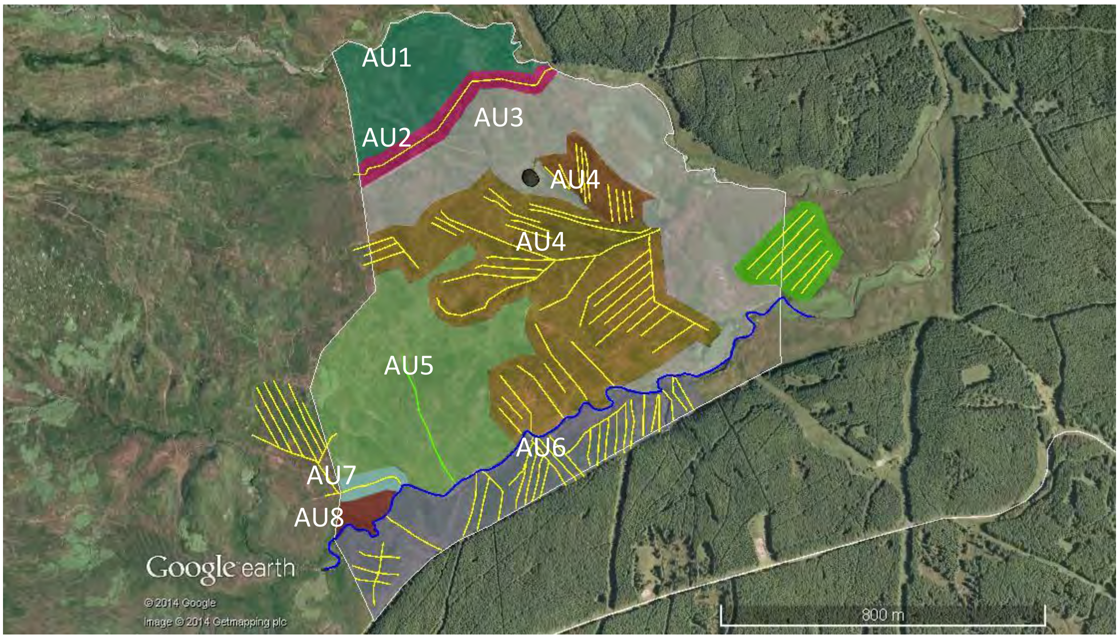


Figure 3. An example Project Site mapped into different Assessment Units based on the Condition Category the different areas appear to be from aerial image (see Figure 4). All drains have been traced with a yellow line to aid mapping into the discrete Assessment Units. Other features have also been marked, such as the rocky outcrop (shown in dark grey towards the centre of the site), the natural watercourse (blue line) and a quad bike track (green line). Marking these features can be helpful when navigating the site in the field and will highlight areas not eligible for the Code (eg. peat depth less than 40cm). This site is mapped into a total of 8 Assessment Units, however, some of these will be very quick to assess in the field (eg. AU2 and AU7). A Project would not necessarily have to include all areas of a site in the Peatland Code. For example, here the landowner could decide that only drain blocking was to be considered, so only Assessment Units 2,4,6 and 8 would be relevant.

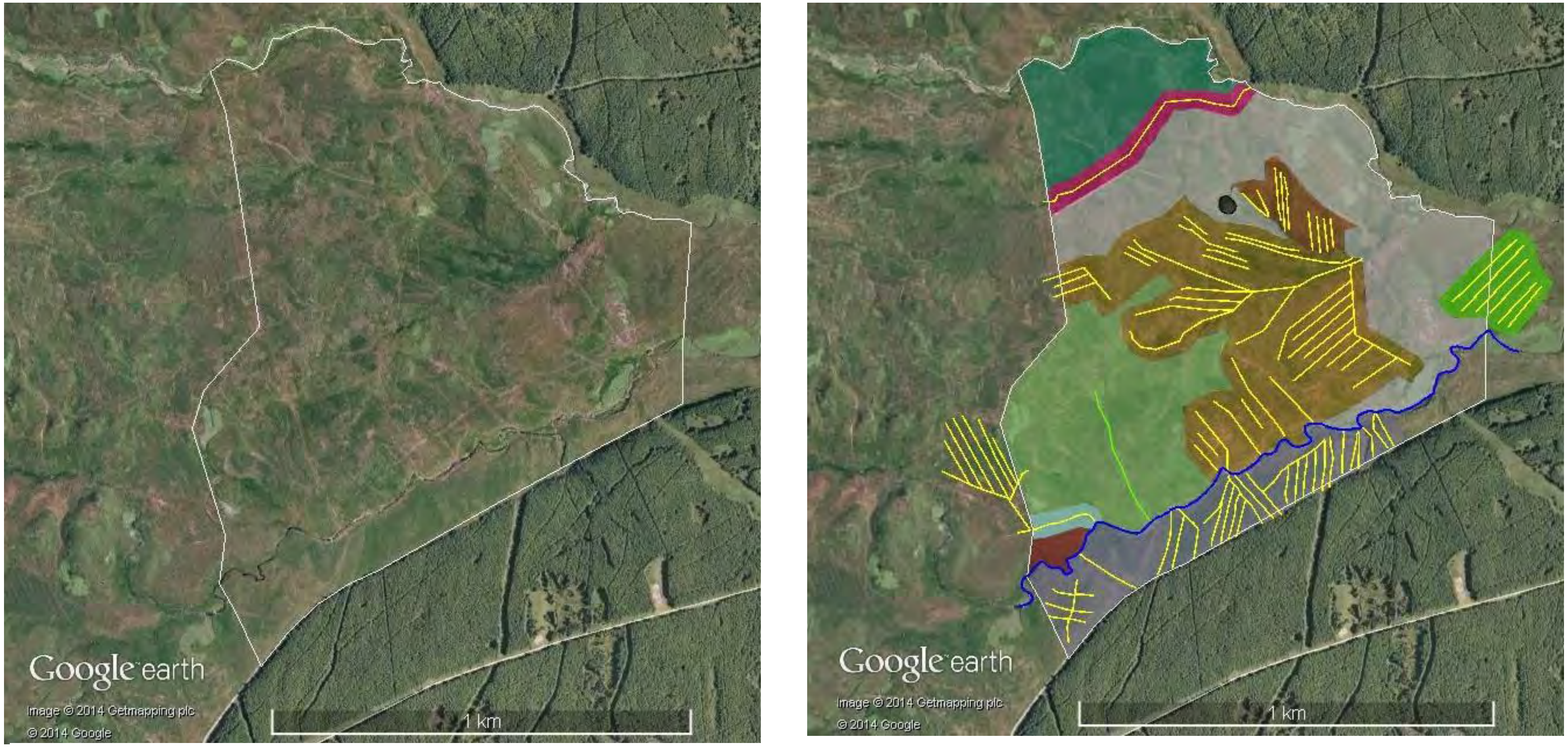


Figure 4. Aerial image (left) and final map showing Assessment Units (right) of an example project site.

Standard Operating Procedure: Mapping

This section describes the steps to take, in sequential order, to produce a map of Assessment Units on which to base the field survey.

1. Using Google Earth or other digital aerial imagery, produce a base map	Assume minimum mapping unit for the restoration site; 0.01ha (10mx10m resolution).
2. Define Project Site	Map as a polygon. Mark fence lines and roads if relevant.
3. Map areas that have bare peat or are hagged	i) Map the hagged and gullied areas. Trace the crest of each hag, gully or peatbank as a red line (or other contrasting colour) onto the map. Repeat the traced line every 2m downslope until the bare peat area is covered to enable the area (width x length) to be calculated (this will also help estimate restoration costs). ii) Map bare peat areas: trace and measure the area of bare peat; map peat pans as a polygon if they are big enough (otherwise map as per hags, with lines and estimate 2m width)
4. Drainage and drains	i) Mark on natural drainage courses in blue ii) If it is artificially drained identify the drains by tracing their lines in yellow (or another contrasting colour) to create an overlay of drains. Define drained area as 30m from outer ditch (or where applicable stop at a fence, boundary of restoration site, break of slope or a natural water course or for raised bogs the ring-ditch if it's before this). For wandering drains across otherwise undrained land, map 30m each side of the drain, creating a 60m stripe. You may wish to measure the total length of the drains from the aerial image in order to help estimate restoration costs.
5. Identify Assessment Units within the Project Site	i) Map onto the aerial image features that are quite clearly forest, rock, and not peat ii) Map the Assessment Units to be surveyed. Each Assessment Unit should reflect the conditions identified above. The number of Assessment Units should be the minimum achievable (join Assessment Units of same condition categories where possible and spatially appropriate). ***See Figures 3 and 4 for an example of a Project Site mapped into Assessment Units***
6. Summary Table	Measure the areas of the units (most mapping software has easy to use tool for this)

2. Field Survey

Purpose

A project site will always have to be surveyed in the field to confidently determine which Condition Categories the areas of peatland fall into. The Assessment Unit map, described in the previous section, provides the structure for the field survey, which has been designed to assess a site using easily identifiable field indicators.

Each Assessment Unit to be included in a Peatland Code Project has to be visited in the field to firstly determine that the unit is eligible for the Peatland Code by meeting 40cm minimum peat depth criteria, and secondly to determine the Condition Category. The field survey will not only help determine the Condition Category of the Assessment Unit pre-restoration, by assessing an Assessment Unit area against the criteria for each Condition Category (**Table 1**), but the most probably change in Condition Category following restoration. This forms the basis for estimating the carbon impact, in terms of greenhouse has emission savings, of restoration. The Peatland Code Condition Categories are specifically designed to assess primarily potential carbon losses, so intentionally relate to habitat functionality. A good functioning bog will not be losing significant amounts of peat, thus carbon, via water pathways or through erosion processes, and will support peat forming species which can thrive in the wet and acidic conditions. As a consequence the key indicators of condition are: extent of Sphagnum moss cover (the primary peat forming species and indicator of the appropriate habitat conditions), extent of bare peat and presence or absence of artificial drains (grips).

The field survey consists of a, two page, tick sheet, and although effective in assessing condition, it is not designed to prescribe the necessary restoration measures. Additional guidance and expertise may have to be sought by the Project for this.

Identifying Condition Categories in the Field

The field survey protocol has been designed to be applicable to sites across the UK, using clear field indicators to determine each of the four condition categories. To help with identifying the criteria of each Condition Category, and the indicators used in the field survey, the following section gives the key criteria of each Condition Category (**Table 1**), provides illustrative images of each, and gives specific information regarding each of the questions asked in the field survey.

Table 1. Peatland Code Condition Category Criteria. *Cannot be assigned an Emissions Factor as not enough UK relevant data.

Peatland Code Condition Category	Description
Pristine*	• Dominated by peat forming species (in most instances *Sphagnum* moss) • Never been modified by landuse: drainage, grazing, burning, pollution
Near Natural	• *Sphagnum dominated* • No known fires • Grazing and trampling impacts scarce or absent • Little or no bare peat • *Calluna vulgaris* absent or scarce
Modified	This category can be split into two further categories (which will help to inform management/restoration plan) **although both will have the same *Modified* Emissions Factor**. <u>Moderately degraded</u> • Infrequent fires • *Grazing and trampling impacts localised and infrequent* • *Sphagnum in parts* • Extent of bare peat limited to small patches • Scattered patches of *Calluna vulgaris* <u>Highly Degraded</u> • *Small discrete patches of bare peat frequent (micro-erosion)* • Frequent fires • Frequent and conspicuous impacts of grazing/trampling • *No/little Sphagnum* • *Calluna vulgaris* extensive
Drained	Within 30m of an artificial drain (grip) or re-vegetated hagg/gully system
Actively Eroding	• Actively eroding hagg/gully system (*most of their length having no vegetation in gully bottoms with steep bare peat "cliffs"*) • Extensive *continuous* bare peat (eg. peat pan) • Extensive bare peat at former *peat cutting* site

Condition Category: Near Natural

Key criteria for near-natural condition is dominance of ***peat forming species***

Pool systems may be present and there will likely be an undulating topography of ***Sphagnum moss hummocks and hollows***

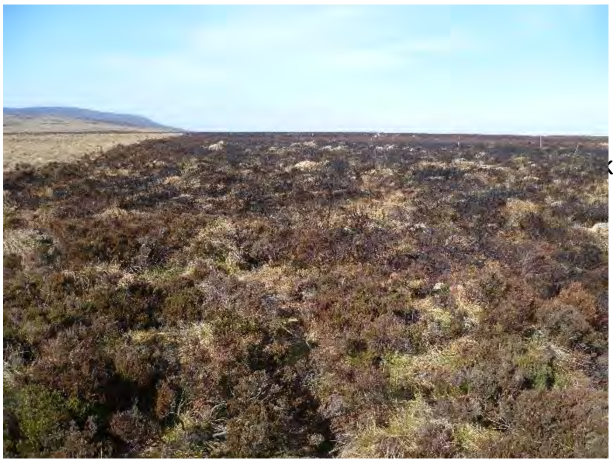
Sphagnum moss is abundant (Sphagnum moss when squeezed will release lots of water unlike other mosses)

Variable micro-topography: vegetation structure is not uniform, Sphagnum hummock and hollows

Condition Category: Modified

Grazing history and information on current management will help determine if a site has been modified due to grazing

Cover of peat forming species (in most instances Sphagnum) will be lower than a near-natural site



Vegetation may be very uniform: with species diversity and structural diversity reduced

Evidence of recent burning may be dead and/or charred heather stems and partly consumed Sphagnum hummocks

Vigorous heather growth can be an indication of drying. However a heather or purple moor grass dominated site may still be near natural if species diversity is high and Sphagnum abundant

It can be difficult to detect evidence of burning in the field (above shows a fire line, indicated by the lack of heather on the left where the fire burned). Management records and information from the land owner on current burning regime may be necessary

Condition Category: Drained



Drains can sometimes be difficult to find in the field, but even apparently grown over drains can be actively draining

Drains which join up with areas of gullying suggest that they are causing erosion of the peat

Sites that have seen historic peat loss can still be causing water table draw-down

Historic peat loss and drying (re-vegetated hagg)

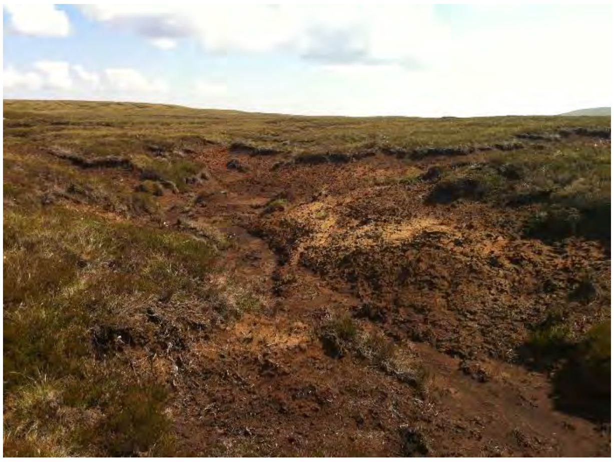
Condition Category: Actively Eroding

Even wet areas can be actively eroding

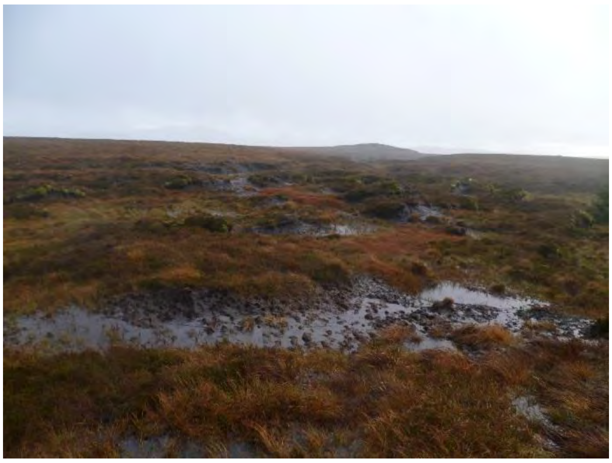
Eroding gully, down to the mineral layer in gully bottom

Patches of bare peat throughout area are frequent, these small bare patches of bare peat indicate “micro-erosion”

Peat haggs can be large and with obvious peat loss



Continual erosion of the peat mass



Erosion can be caused, or exacerbated by trampling by animals, so can be quite localised

Field Survey: Tick Sheet

This section describes how to complete the Field Survey Tick Sheet. The Tick Sheet asks the users a series of questions so the Condition Category of each Assessment Unit can be confirmed/determined in the field (Figure 5). The Tick Sheet requires the user to complete three Condition Assessments (three Condition Assessments are presented on one Tick Sheet) at different locations per Assessment Unit (so one Tick Sheet per Assessment Unit). The survey methodology is given in the Standard Operating Procedure.

The Tick Sheet can either be printed and completed with pencil in the field or used as a Microsoft Excel spreadsheet on a suitable handheld device.

Both the Tick Sheet and a step by step guide for users can be found at the back of this booklet.

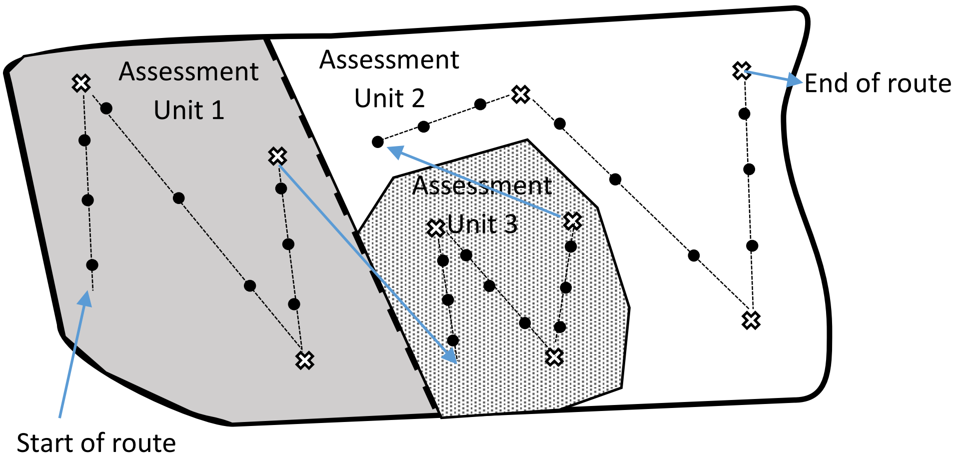


Figure 5. Schematic of Assessment Unit field survey for a representative site with three Assessment Units. Dotted lines show route walked with black dots location of peat depth measurements. Arrows show walk between Assessment Units. Crosses mark the location for Condition Assessments (three per Assessment Unit) carried out in conjunction with a peat depth measurement.

Identifying Indicators of Condition

The following section further explains each of the condition indicators, described in questions 1 to 5, in the Tick Sheet. Each indicator will help determine which Condition Category a particular Assessment Unit will be ascribed. Should a situation arise where a site is deemed not to meet the criteria of any of the Condition Categories, advice should be sought from the Peatland Code. It should be remembered that the Peatland Code Condition Categories are based on the criteria presented in Table 1.

Q1 Is the area eroding?

Presence of actively eroding hags/gullies with no/limited vegetation in gully bottom

- Actively eroding haggs are those with bare peat sides. There may be obvious signs that peat is continually being lost (eg. chunks of peat at bottom of hagg, pock marks caused by frost heave and wind action).
- Haggs will probably be steep (the top vegetated layer has probably not collapsed over the bare peat side of a hagg)
- A lack of vegetation in a gully bottom indicates the gully bottom is still actively eroding

Extensive continuous bare peat

- This could be a result of a severe fire, peat extraction (eg. cut-over raised bog), long term peat loss, trampling by livestock

No extensive bare peat or actively eroding hags/gullies, vegetation abundant in gully bottoms

- This makes the distinction between an actively eroding gully and a re-vegetated "stable" gully. ***Nb.*** *Gully bottoms must meet the 40cm minimum peat depth criteria to be included in the Code.*
- If clearly a "healed" (re-vegetated) hagg and gully system, not being actively eroded, this would be considered to meet the criteria for the Peatland Code *Drained* Condition Category rather than *Actively Eroding*
- If no signs of active erosion of the peat mass, then the area will eventually be ascribed to one of the other Condition Categories by continuing to follow the questions

To note:

- You can have a situation where gully bottoms are re-vegetated but haggs are still eroding. If this is the case haggs will have to be mapped as Actively Eroding, while the surrounding area would be mapped as Drained. When mapping this situation (to calculate area of each Condition Category for

GHG calculations) it may be easiest to calculate the drained area as total Assessment Unit area minus hagg area (total length of eroding haggs x width).

An example of when a gully bottom (hagg flat) is re-vegetated and not eroding but hagg is still actively eroding

Q2 Is the area drained?

Drains (grips) or re-vegetated haggs/gullies present within 30m of location of Condition Assessment

- Both these features would have a draw-down effect on the water table so the area would be described as drained

No drains (grips) or re-vegetated haggs/gullies present within 30m of location of Condition Assessment

- Assumption now is that any drying in the area will not have been caused by artificial drains

Q3 Extent of bare peat (walk 20 paces to assess)

Small discrete patches bare peat frequent

- This indicates micro-erosion
- Could be caused by trampling by animals (sheep, deer, goats, cows)
- It may also be as a result of a fire which has consumed vegetation and/or peat in patches
- **NB.** If bare peat is extensive and continuous, and over the 20 paces walked the majority (>75%) of footsteps fall on bare peat, then this area

should be considered against the criteria for the *Actively Eroding* Condition Category

None/Small discrete patches bare peat infrequent

- Small discrete patches of bare peat are at most very localised, ie. very unusual on the site

Q4 Extent of Sphagnum

Sphagnum dominated

- Sphagnum is abundant, and an almost continuous layer underfoot
- Sphagnum is strongly associated with a high water table and some of the common species such as *Sphagnum magellanicum*, *Sphagnum papillosum* and *Sphagnum capillifolium* are associated with lower pH. This makes the extent of Sphagnum cover a practical indicator of good bog condition.

Sphagnum in parts

- Sphagnum may occur in patches or may be limited to wetter areas such as down old ditches and in depressions

No obvious Sphagnum layer

- If the Sphagnum layer has been lost it suggests that the site is drier, with a lower water table
- A lack of Sphagnum may also indicate a reduction, or loss, of peat forming function. However, it is recognised that some other species such as purple moor grass and cotton grasses can be important peat forming species in some areas. Advice can be sought from the Peatland Code if it is felt a lack of Sphagnum does not indicate a reduction in bog functionality (hydrology, peat forming functionality is intact).

Q5 Vegetation and Management Indicators

Burning

- The frequency of fires, both management fires and wildfires, at the site should be assessed over a 50 year period
- This indicator uses fire severity as an indication of the impact of burning at a site as fire severity (in terms of the ecological impact of a fire) can be difficult to ascertain in the field, particularly if some years have passed since the fire
- Where there have been infrequent fires at a site but they have been very ecologically damaging this should be captured by the other indicators in Q5 or may be the cause of a site being ascribed the *Actively Eroding* Condition Category.

No known fires

- No known fires have occurred within the last 50 years (most likely indicated by management records)

Infrequent fires

- This would indicate a scenario where fires (including management fires) happen infrequently. They may be wildfires which could have occurred a couple of times within the last 50 years or management fires where rotation times are long (eg. 20 years plus).

Frequent burning

- This is specifically designed to capture a scenario where there is an intensive burning regime, where rotation times are short (eg. 10 years or less)
- Information will come from management records but the site will also have the typical “mosaic” of short and longer grass/heather and recently burned patches which will likely be obvious on aerial images.

Unknown

- If it is not possible to ascertain if the site has been burned in the last 50 years then this option should be ticked. This means that this indicator is not used to determine the final Condition Category.

Grazing and Trampling

- This indicator specifically looks at the ***current*** impact of grazing and trampling at a site. There may be historical impacts of grazing at a site, such as a change in vegetation structure and composition, which will be picked up in other questions.
- Identifying any negative impacts the current grazing regime is having will be important for informing future management of the site and the changes that have to be made to improve Condition Category or maintain good condition.
- It can be difficult to assess the impact the current grazing regime is having on vegetation. Looking either side of a fenceline or enclosure may be helpful. However, if grazing density is known to be high (Scottish Natural Heritage for example suggests a stocking density for open bog of 0.02 LU/ha/yr or less[1]), from knowledge of the site and management records, then this could help assess impacts. However, it is still important to assess extent of trampling and poaching and to appreciate that other animals such as deer and goats may be an added pressure.

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[1] Guidance for land managers - Grazing peatland, Peatland Action. (2014) http://www.snh.gov.uk/docs/A1268255.pdf [Accessed on 31/03/2015]

Drying and Peat Loss

Extent of Sphagnum

- As described above. This question is included in Q5 to help determine if a site is *Highly* or *Moderately* degraded.

Extent of bare peat

- The extent of bare peat is important to consider as it can identify the potential for a site to loose significant amounts of carbon. Bare peat patches may be caused by fire, animal impacts and walkers for instance.

Vegetation Composition

- This question will help ascertain if vegetation composition is poor, dominated by a single species, such as heather (*Calluna vulgaris*), or supports atypical vegetation for a bog. Scrub (for instance birch) may indicate drier than ideal conditions on a lowland raised bog.
- Even if a site supports extensive areas of one species, such as heather (*Calluna vulgaris*), it could still be classified as Near Natural if Sphagnum is dominant throughout.
- Scattered patches of heather or purple moor grass (*Molinia caerulea*) may be confined to dry ridges or areas adjacent to drains.

Standard Operating Procedure: Field Survey

1. Plan your walking route through the site	Remember you will need to check each of the Assessment Units: eg. *Actively Eroding* area, *Drained*, and the other areas. Identify a walk (zigzag transect) through each of the units. *See Figure 5 for schematic representation of survey methodology.*
2. Check Assessment Unit boundaries	*Field Survey Tick Sheet Section 3:* Redraw/reassess if necessary. Sense check: does the peat look as if it will qualify as peat under the Peatland Code (is it more than 40cm deep, do depth checks; are there many rocks showing?). You may find the landcover maps unhelpful in the field.
3. Peat depth checks	*Field Survey Tick Sheet Section 5:* Do 12 peat depth checks, at fairly regular intervals, in each Assessment Unit by walking along the zigzag path, waymarking the route using (GPS) grid references. At every 4th stop you will do a Condition Assessment (see below) i) Check the peat is deep enough. To qualify under Peatland Code, peatland is defined as area dominated by peat over 40cm deep. For the field survey, 'dominated' means more than 66% of the observations within a unit should be over 40cm deep. (i.e. 8 out of 12 measurements must 'pass') ii) Tick the peat depth categories on the Tick Sheet (tick less than <40cm or > 40cm; and if less than 40cm in a drained area, give a measurement). *NB. other sources of funding for peatland restoration may require a different peat depth survey methodology (eg. Peatland Action)* iii) In gullied/eroding systems, measure the height of the peat haggs (i.e. the max peat depths) not the eroded flats, to check they are over 40cm iv) In drained areas, where the drains should be blocked, there is no minimum depth criteria. You will still need to measure depth to know how much less below 40cm it is (this can help inform restoration measures).
4. Condition Assessments	At every 4th peat depth measurement, waymark/note the grid ref, and assess which Condition Category the peatland is in by doing a Condition Assessment. Decide which of the 4 categories (*Near Natural*, *Modified*, *Actively Eroding* or *Drained*) the peatland is in now. a) Assess extent of bare peat. Verify air photo maps for: i) continuous/extensive bare, unvegetated peat (may have shallow rills/incipient gullying and sheet wash); extensive areas of oxidised dry bare peat on flat or gently sloping ground; deflation flats (areas stripped by wind erosion) and wind hagg fields (wind stripped but with some haggs peat remaining): classify as *Actively Eroding*. ii) micro-erosion peat or incipient bare peat - bare peat showing through a thin cover of live or dead plant material or completely bare peat in small

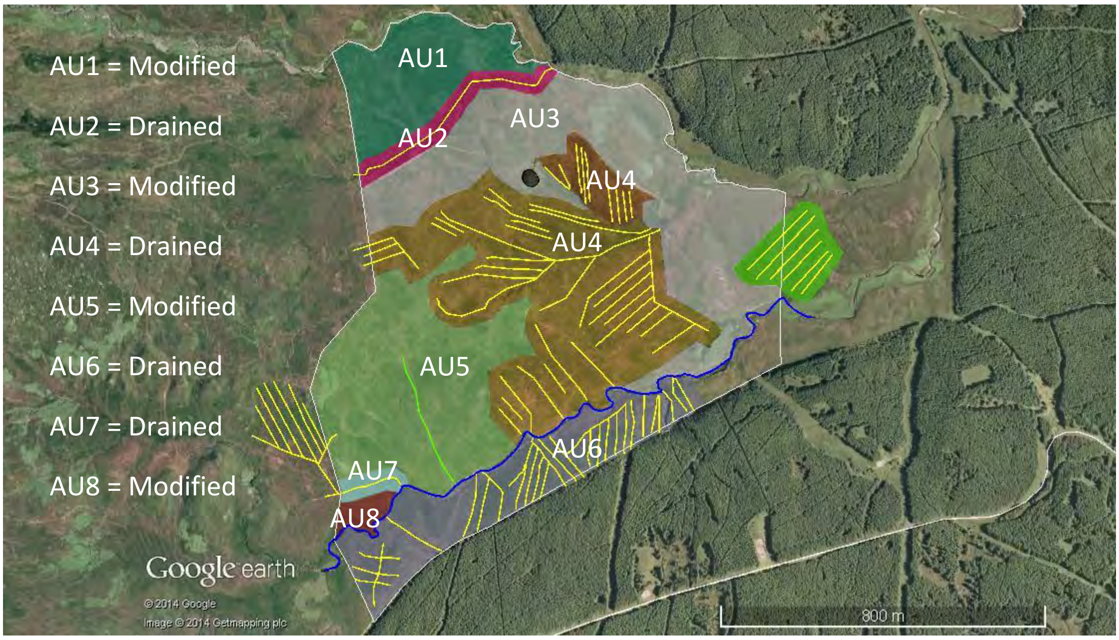
	sparse patches (generally with intact vegetation with small patches of bare peat) and evidence of cracking. Even small areas of bare peat should be recorded (presence or absence). b) In gullied areas, check that the mapped haggs are active; are these areas really eroding? If the answer is yes then classify as *Actively Eroding*. If it is healing, if there is vegetation cover on the flat areas and there are no or a limited number of vertical peat banks, classify as *Drained*, ie. small peat accumulation and the hydrology of an area is still likely to be affected. c) In drained areas, check – is it drained or within 30m of a drain?

3. Confirmation of site condition(s)

Current Condition(s)

After undertaking three Condition Assessments in each of the Assessment Units during the field survey, as described in the previous section, each Assessment Unit can now be described by its Condition Category. This is the Condition Category the areas can be described as in their current state (ie. the time of the survey).

The example Project below shows that Assessment Units either fall into the *Drained* or *Modified* categories (ie. when the site is not drained it is best described as *Modified* due to current evidence of moderate grazing pressure).



Predicted Condition(s)

In order to determine the emissions savings from restoration, or the emissions loss if degradation is not halted, the Condition Categories of each Assessment Unit have to be predicted in both a restoration and no-restoration scenario. The following section describes the default condition change but in some instances, with a comprehensive understanding of a site, a Project may make the case for different outcomes. In all instances the predicted changes will be verified by the Peatland Code. It is important to remember that with changing management regimes and practices current Condition Categories have the potential to change into any of the four Condition Categories in the future. The defaults are given for an illustrative 30 year Peatland Code Project and may vary with longer projects (Figure 6). In the example Project used here it is predicted that both the *Modified* and the *Drained* areas will become *Near Natural* over the 30 years of the project. This is because all the drains are getting blocked, returning the water table to its natural position and grazing is being reduced.

Predicted Category	Key Criteria
Near Natural	Post restoration a site must provide the necessary conditions for peat formation usually through the raising of the water table (following drain blocking) and be dominated by peat forming species (in most instances Sphagnum), have no, or very, limited bare peat (as described in Tick Sheet), and not be negatively impacted by grazing and/or burning
Modified	A site can be returned to a *Modified* state from a *Drained* state through restoration action such as drain blocking, raising the water table. However, the site is described as *Modified* if Sphagnum is still limited in its cover and if there are discernable negative impacts of grazing and/or burning.
Drained	A site that has been artificially drained with no restoration or has been *Actively Eroding*, even with restoration. A restored site which was *Actively Eroding* is best described as *Drained* post restoration as it is unlikely the hydrology of the site will be restored fully. This is even considered to be the case if there is evidence of peat accumulation in gully bottoms.
Actively Eroding	If the current condition of a site is *Actively Eroding* then without intervention the site will continue to erode, increasing peat loss and emissions to the atmosphere.

Default Condition Changes

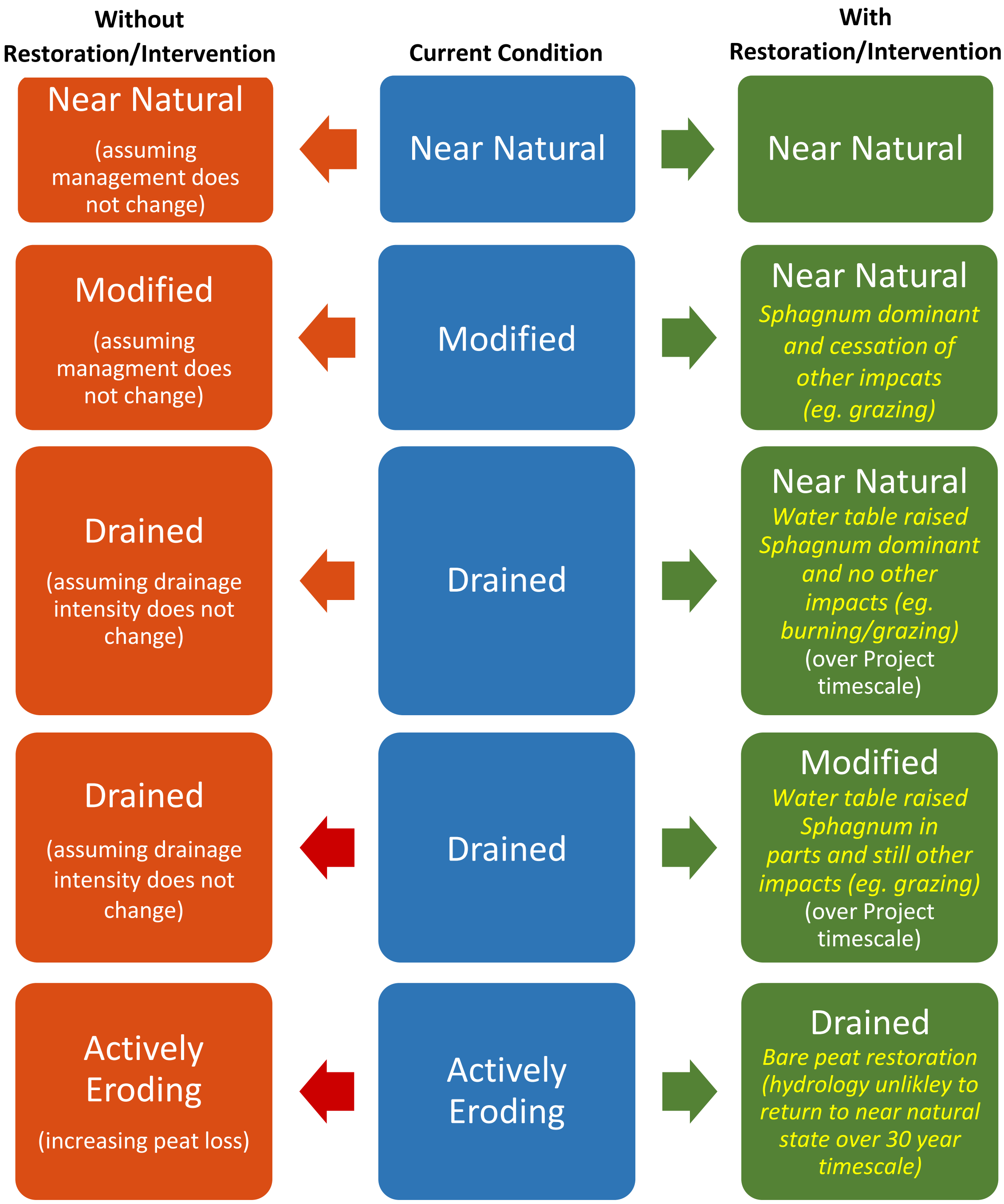


Figure 6. Default Condition Category changes following restoration. This does not however preclude other Condition Category changes.

tCO$_2$ eq/ha/yr

4. Calculating emissions savings

Purpose

The purpose of calculating emissions savings brought about by the peatland restoration activities undertaken by a Peatland Code Project is to estimate the income that can be generated by selling the associated carbon credits on the carbon market. By following each of the three preceding steps the emissions savings for a project, given as tonnes of CO_2 equivalents[2] per hectare per year (tCO_2 eq/ha/yr), can be calculated from the change in Condition Categories for each Assessment Area.

Calculating Emissions

To calculate the expected impact of a Peatland Code project on emissions each Condition Category has been given an Emissions Factor based on the most up to date and relevant scientific research. By assigning each Condition Category an Emissions Factor the impact of a Project can be calculated from the anticipated change in Condition Categories. Table 2 shows the impact on emissions for each Condition Change.

Within the Peatland Code Project Feasibility tool there is a worksheet designed to allow a Project to calculate emission savings brought about by restoration and management. The only information needed for this tool is the area of each Assessment Unit and its current and post restoration Condition Category.

Table 2 Effect on emissions by changing Condition Categories, calculated using the Peatland Code Emission Factors.

Condition State Change	Net Effect (t CO_2 eq ha^{-1} $yr^{-)}$
Restoring from Modified to Near Natural	Saves 1.46
Restoring from Drained to Near Natural	Saves 3.46
Restoring from Drained to Modified	Saves 2.00
Restoring Actively Eroding to Modified	Saves 21.30
Restoring Actively Eroding to Drained	Saves 19.3
Allowing Drained to develop into Actively Eroding	Loses 19.3

[2] CO_2 equivalents is a metric measure used to make greenhouse gases, with their different Global Warming Potentials (GWP), comparable through converting their different GWP's.

5. Further Information

Contact

Further information can be found in the Frequently Asked Questions Section but for information and guidance on specific issues surrounding the Field Protocol then the Peatland Code should be contacted[3].

Frequently Asked Questions

1. My site is a mosaic of different peatland conditions, how do I map this?

When a project site is difficult to map into discrete Assessment Units because it is a continuous mixture of conditions or a mosaic of peatland and for example, shallow peat/rocky outcrop (not eligible for the Peatland Code), then Assessment Units/Condition Categories can be estimated as a percentage of the total site area. This estimate would, however, would have to be verified by the Peatland Code.

2. I am unsure what Condition Category one of the areas of the Project will become with restoration. What should I do?

It is very important to take into consideration the future management of the area as for instance a drained area will not be returned to near natural following drain blocking if it is still being impacted by grazing. Expert opinion may have to be sought by the Project to determine the likely future impact of restoration and management regimes. Looking to sites nearby that have been restored or managed in a similar way may help determine what is likely for your site.

3. My initial Project site has 5 Assessment Units but the landowner does not want to ditch block the whole area. Can I restore only part of an Assessment Unit or Project Area?

When only a limited amount of drain blocking can be undertake it is important that the works make "hydrological sense". This means as far as possible, even if

[3] It is recommended that the Peatland Code needs a formal system for verifying survey results and a contact point for prospective projects to get advice and further information on the Field Protocol.

considering a small area, drain blocking should be carried on a sub-catchment scale.

4. My site has been restored already: the drains have already been blocked and haggs re-profiled. How do I assess this site?

If restoration has been successful and you can demonstrate that the water table has been raised over a given area then this site would likely be classed as Modified or Near Natural using the Field Protocol. Likewise if a, Actively Eroding hagg has been re-profiled the area would probably be classed at Modified using the Field Protocol. Ie. it is the current state of the site that is assessed.

1 Project Details

Project Site Name		Assessment Unit ID		Date of Survey	

2 Dominant Condition Category

Tick appropriate box after three Condition Assessments

Near Natural ☐ Actively Eroding ☐ Drained ☐ Modified Condition Category: Moderately Degraded ☐ Highly Degraded ☐

3 Assessment Unit Boundary confirmed by ground assessment?

Assessment Unit Boundary confirmed by ground assessment? Yes ☐ No ☐

If no, please describe amendments

4 Grid References

Record grid ref. and time at start of route through Assessment Unit and on reaching each CA location

	Grid Reference	**Time** (HH:MM)	**Brief Description**	**Photo**
Start of route				☐
Condition Assessment 1 (**CA1**)				☐
Condition Assessment 2 (**CA2**)				☐
Condition Assessment 3 (**CA3**)				☐

5 Peat Depth Check

Tick appropriate box for each depth check measurement

	Location at which to take depth measurements											
	From Assessment Unit Boundary to CA1			**At CA1**	On walk between CA1 and CA2			**At CA2**	On walk between CA2 and CA3			**At CA3**
	1	2	3	4	5	6	7	8	9	10	11	12
>40cm												
<40cm												
Depth (cm)*												

** Accurate depth measurement only needed on drained sites with a peat depth <40cm*

6 Condition Assessments

Tick appropriate box for each Condition Assessment following questions (in bold) until Condition Category (in italics) reached

	CA1	**CA2**	**CA3**
Q1 Is the area eroding? *(refer to guidance)*			
Presence of actively eroding hags/gullies with no/limited vegetation in gully bottom	☐ *Actively Eroding*	☐ *Actively Eroding*	☐ *Actively Eroding*
Extensive continuous bare peat	☐ *Actively Eroding*	☐ *Actively Eroding*	☐ *Actively Eroding*
No extensive bare peat or actively eroding hags/gullies, vegetation abundant in gully bottoms	☐ ***Go to Q2***	☐ ***Go to Q2***	☐ ***Go to Q2***
Q2 Is the area drained?			
Drains (grips) or re-vegetated haggs/gullies present within 30m of location of CA	☐ *Drained*	☐ *Drained*	☐ *Drained*
No drains (grips) or re-vegetated haggs/gullies present within 30m of location of CA	☐ ***Go to Q3***	☐ ***Go to Q3***	☐ ***Go to Q3***
Q3 Extent of bare peat (walk 20 paces to assess)			
Small discrete patches bare peat frequent	☐ *Highly Degraded*	☐ *Highly Degraded*	☐ *Highly Degraded*
None/Small discrete patches bare peat infrequent	☐ ***Go to Q4***	☐ ***Go to Q4***	☐ ***Go to Q4***
Q4 Extent of *Sphagnum*			
Sphagnum dominated	☐ *Near Natural*	☐ *Near Natural*	☐ *Near Natural*
Sphagnum in parts	☐ ***Go to Q5***	☐ ***Go to Q5***	☐ ***Go to Q5***
No obvious Sphagnum layer	☐ ***Go to Q5*****	☐ ***Go to Q5*****	☐ ***Go to Q5*****

Q5 Vegetation and Management Indicators

Tick box with most appropriate statement for each group of indicators (refer to guidance)

	CA1	CA2	CA3
Burning (in last 50 years) Evidence may come from aerial/field survey and management records (*as part of intensive management regime)	No known fires ☐ NN Infrequent fires ☐ M Frequent burning* ☐ H Unknown ☐	No known fires ☐ NN Infrequent fires ☐ M Frequent burning* ☐ H Unknown ☐	No known fires ☐ NN Infrequent fires ☐ M Frequent burning* ☐ H Unknown ☐
Grazing and Trampling Evidence of heavy grazing (extent of bare peat patches cause by trampling/wallowing, extent and frequency of paths, extent of browsed/grazed vegetation)	Very scarce or absent ☐ NN Localised and infrequent ☐ M Frequent and conspicuous ☐ H	Very scarce or absent ☐ NN Localised and infrequent ☐ M Frequent and conspicuous ☐ H	Very scarce or absent ☐ NN Localised and infrequent ☐ M Frequent and conspicuous ☐ H
Drying and Peat Loss			
Presence of Sphagnum	Conspicuous and dominant. ☐ NN In parts ☐ M Absent ☐ H	Conspicuous and dominant. ☐ NN In parts ☐ M Absent ☐ H	Conspicuous and dominant. ☐ NN In parts ☐ M Absent ☐ H
Extent of bare peat	Mostly well vegetated little peat exposed ☐ NN Limited to small sparse patches over small areas ☐ M Large and extensive areas ☐ H	Mostly well vegetated little peat exposed ☐ NN Limited to small sparse patches over small areas ☐ M Large and extensive areas ☐ H	Mostly well vegetated little peat exposed ☐ NN Limited to small sparse patches over small areas ☐ M Large and extensive areas ☐ H
Vegetation Composition: Cover of heather (*Calluna*)/Purple moor grass/Scrub (eg. birch), atypical vegetation	Absent/scarce ☐ NN Scattered patches ☐ M Conspicuous and extensive ☐ H	Absent/scarce ☐ NN Scattered patches ☐ M Conspicuous and extensive ☐ H	Absent/scarce ☐ NN Scattered patches ☐ M Conspicuous and extensive ☐ H

Number of ticks per category

	CA1	CA2	CA3
Near Natural (NN)	NN ☐	NN ☐	NN ☐
Moderately Degraded (MD)	MD ☐	MD ☐	MD ☐
Highly Degraded (HD)	HD ☐	HD ☐	HD ☐

Dominant Condition Category *(category with most ticks**)*

***where Sphagnum not dominant only count categories MD and HD*

CA1	CA2	CA3
☐	☐	☐

Additional notes if required *eg. evidence of grazing/other impacts/uncertainties*

Guidance for Completing Field Survey Tick Sheet

1 **Project Details**

Project Site Name	Bog Hill	Assessment Unit ID	AU1	Date of Survey	23/03/2015

Fill out site details and the name of the Assessment Unit you are surveying.

2 **Dominant Condition Category** *Tick appropriate box after three Condition Assessments*

Near Natural ☐ Actively Eroding ☐ Drained ☐ Modified Condition Category: Moderately Degraded ☑ Highly Degraded ☐

Once **all three Condition Assessments are completed** (CA1, CA2 and CA3) the dominant condition category can be determined and this section filled in.

3 **Assessment Unit Boundary confirmed by ground assessment?** Yes ☐ No ☑

If no, please describe amendments

No, the western edge is not over deep peat, need to take out roughly 20m from mapped edge

If in the field it is apparent that the Assessment Unit boundary line drawn on the original aerial image is not correct then please describe amendments needed here.

4 **Grid References** *Record grid ref. and time at start of route through Assessment Unit and on reaching each CA location*

	Grid Reference	Time (HH:MM)	Brief Description	Photo
Start of route	NX 5421 7654	14:32	Started route at gate onto site	☑
Condition Assessment 1 (**CA1**)	NX 6110 7002	14:59	Near to telegraph pole	☑
Condition Assessment 2 (**CA2**)	NX 6901 5001	15:23	Walking towards stream, stopped before rocky knoll	☑
Condition Assessment 3 (**CA3**)	NX 7019 6542	16:01	Stopped before edge of bog and gate off site	☑

Record the grid reference at the start of your route and at the spots where the 3 Condition Assessments are carried out. Recording the time will help to relate any photographs taken to areas along the route. Space is available here to describe the route, recording obvious features which will help locate the route in the future.

5 **Peat Depth Check** *Tick appropriate box for each depth check measurement*

	Location at which to take depth measurements											
	From Assessment Unit Boundary to CA1			At CA1	On walk between CA1 and CA2			At CA2	On walk between CA2 and CA3			At CA3
	1	2	3	4	5	6	7	8	9	10	11	12
>40cm	√	√	√	√	√	√		√	√	√		√
<40cm							√				√	
Depth (cm)*							22				35	

** Accurate depth measurement only needed on drained sites with a peat depth <40cm*

Confirm that peat depth meets the 40cm depth criteria for Peatland Code along the route taken through the Assessment Unit. Record the actual depth when less than 40cm deep. This is the minimum requirement for verifying that the peat depth in an Assessment Unit meets the Peatland Code 40cm depth criteria, and a more detailed survey may be required by other funders or to inform management.

6 Condition Assessments

Tick appropriate box for each Condition Assessment following questions (in bold) until Condition Category (in italics) reached

	CA1	CA2	CA3
Q1 Is the area eroding? *(refer to guidance)* Presence of actively eroding hags/gullies with no/limited vegetation in gully bottom	☐ *Actively Eroding*	☐ *Actively Eroding*	☐ *Actively Eroding*
Extensive continuous bare peat	☐ *Actively Eroding*	☐ *Actively Eroding*	☐ *Actively Eroding*
No extensive bare peat or actively eroding hags/gullies, vegetation abundant in gully bottoms	☑ ***Go to Q 2***	☑ ***Go to Q 2***	☑ ***Go to Q 2***
Q2 Is the area drained? Drains (grips) or re-vegetated haggs/gullies present within 30m of location of CA	☐ *Drained*	☐ *Drained*	☐ *Drained*
No drains (grips) or re-vegetated haggs/gullies present within 30m of location of CA	☑ ***Go to Q3***	☑ ***Go to Q3***	☑ ***Go to Q3***
Q3 Extent of bare peat (walk 20 paces to assess) Small discrete patches bare peat frequent	☐ *Highly Degraded*	☐ *Highly Degraded*	☐ *Highly Degraded*
None/Small discrete patches bare peat infrequent	☑ ***Go to Q4***	☑ ***Go to Q4***	☑ ***Go to Q4***
Q4 Extent of *Sphagnum* Sphagnum dominated	☐ *Near Natural*	☐ *Near Natural*	☐ *Near Natural*
Sphagnum in parts	☑ ***Go to Q5****	☑ ***Go to Q5****	☑ ***Go to Q5***
No obvious Sphagnum layer	☐ ***Go to Q5****	☐ ***Go to Q5****	☐ ***Go to Q5****

Tick the statement that best describe the area surrounding each Condition Assessment (CA) location.

For each Condition Assessment (CA1, CA2, CA3) follow questions vertically down page ticking each statement as you go.

If no "Go to" instructions given then you have determined the category and no longer need to carry on with the questions.

If there is no obvious Sphagnum layer proceed to Q5 ***but the category cannot be described as the Peatland Code Condition Category Near Natural.***

Q5 Vegetation and Management Indicators

Tick box with most appropriate statement for each group of indicators (refer to guidance)

	CA1		CA2		CA3	
Burning (in last 50 years) Evidence may come from aerial/field survey and management records (*as part of intensive management regime)	No known fires	☐ NN	No known fires	☐ NN	No known fires	☐ NN
	Infrequent fires	☑ M	Infrequent fires	☑ M	Infrequent fires	☑ M
	Frequent burning*	☐ H	Frequent burning*	☐ H	Frequent burning*	☐ H
	Unknown	☐	Unknown	☐	Unknown	☐

Q5 is designed to further refine the condition of the Assessment Unit and considers the impacts of management practices. Additional information can come from management records.

Tick the statement in each section that best describes the area surrounding each Condition Assessment location. For each Condition Assessment (CA1, CA2, CA3) follow questions vertically down the page ticking each statement as you go. I = Intact (ie. functionally intact), MD = Moderately Degraded, HD = Highly Degraded **Although both Moderately Degraded and Highly Degraded bogs will be assigned to the "Modified" category when estimating carbon emissions asking to make the distinction between the two in the field will help inform management and restoration plans.**

Grazing and Trampling			
Evidence of heavy grazing (extent of bare peat patches cause by trampling/wallowing, extent and frequency of paths, extent of browsed/grazed vegetation)	Very scarce or absent [ ] NN Localised and infrequent [x] M Frequent and conspicuous [ ] H	Very scarce or absent [ ] NN Localised and infrequent [x] M Frequent and conspicuous [ ] H	Very scarce or absent [ ] NN Localised and infrequent [ ] M Frequent and conspicuous [x] H
Drying and Peat Loss			
Presence of Sphagnum	Conspicuous and dominant. [ ] NN In parts [x] M Absent [ ] H	Conspicuous and dominant. [ ] NN In parts [x] M Absent [ ] H	Conspicuous and dominant. [ ] NN In parts [ ] M Absent [x] H
Extent of bare peat	Mostly well vegetated little peat exposed [ ] NN Limited to small sparse patches over small areas [x] M Large and extensive areas [ ] H	Mostly well vegetated little peat exposed [ ] NN Limited to small sparse patches over small areas [x] M Large and extensive areas [ ] H	Mostly well vegetated little peat exposed [ ] NN Limited to small sparse patches over small areas [x] M Large and extensive areas [ ] H
Vegetation Composition: Cover of heather (*Calluna*)/Purple moor grass/Scrub (eg. birch), atypical vegetation	Absent/scarce [ ] NN Scattered patches [x] M Conspicuous and extensive [ ] H	Absent/scarce [ ] NN Scattered patches [x] M Conspicuous and extensive [ ] H	Absent/scarce [ ] NN Scattered patches [ ] M Conspicuous and extensive [x] H

Tick the statement in each section that best describes the area surrounding each Condition Assessment location. For each Condition Assessment (CA1, CA2, CA3) follow questions vertically down the page ticking each statement as you go. I = Intact (ie. functionally intact), MD = Moderately Degraded, HD = Highly Degraded

Although both Moderately Degraded and Highly Degraded bogs will be assigned to the "Modified" category when estimating carbon emissions asking to make the distinction between the two in the field will help inform management and restoration plans.

Number of ticks per category						
Near Natural (NN)	NN	0	NN	0	NN	0
Moderately Degraded (MD)	MD	5	MD	5	MD	2
Highly Degraded (HD)	HD	0	HD	0	HD	3

Dominant Condition Category *(category with most ticks**)*

***where Sphagnum not dominant only count categories MD and HD*	MD	MD	HD

Additional notes if required *eg. evidence of grazing/other impacts/uncertainties*

This section determines ultimately whether a site is Near Natural or Modified (meeting the criteria for sub-categories Moderately or Highly Degraded).

If a site does not have any Sphagnum then it can not be classified as the Peatland Code Condition Category Near Natural

In some instances it may not be possible to confidently ascribe one of the Modified sub-categories: Moderately or Highly Degraded to a site. However this does not affect calculating greenhouse gas emissions as both sub-categories use the Modified Emissions Factor. The information gathered here may still however help inform future management of the site and help identify problem areas.