Scoping the Natural Capital Accounts for Peatland

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1. Scoping the Natural Capital Accounts for Peatland

1.0 Summary

This note scopes the development of a peatland account within the developing UK environmental accounts, and forms Work Package 3 of Defra project NR0165. It has drawn on the material in NR0165 (Smyth *et al* 2014), and in developing work on UK natural capital 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[1] 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[2]. 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.

[1] 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.
[2] 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[3]
- 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.

1.1 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[4], 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] Deep, water-logged peat is an unfossilised coal seam, it only affects climate when its carbon comes out of storage.
[4] https://www.wavespartnership.org/sites/waves/files/documents/PTEC2%20-%20Ecosystem.pdf

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
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 paper 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.

1.2 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[5], 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 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[6].

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 UKNEA 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".

Figure 1 (overleaf) illustrates how peat is the ecosystem asset underneath the land cover. Where it is kept damp or blanketed in moss, and not covered in forestry, dry heather, grazed grass or arable crops, it can sequester carbon. Such natural peat habitats include blanket bog, raised bog and fen/marsh/swamp.

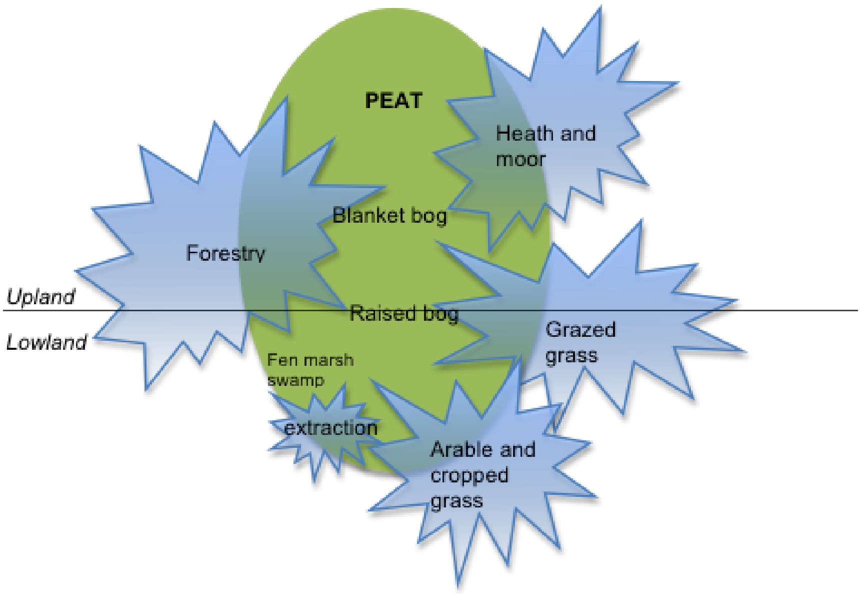
Variations in condition mean that peatlands can move between these classifications within a few decades. For example, some raised or blanket bogs can dry out (due to drought and/or drainage), and become 'heaths'. Sometimes these can be restored back to 'bog' (i.e. wetland) status by raising water levels. 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

[5] 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.

[6] 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.

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).

Figure 1: Peat and land cover



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[7]. 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[8], 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.

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

[7] http://jncc.defra.gov.uk/protectedsites/sacselection/habitat.asp?FeatureIntCode=H91D0
[8] 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)

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.[9] 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 1)

Table 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*	

[9] **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

1.3 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[10], 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[11].

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. The following table outlines best estimates, as per interim reports for NR0165.

[10] JNCC 2011. Towards an assessment of the state of UK peatlands, Joint Nature Conservation Committee Report No. 445. Peterborough.

[11] 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 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[12]	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

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

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 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.

1.4 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[13]. 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

[13] 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.

- 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.

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:

Table 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 (eg 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 bb 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 is 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
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 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[14] 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 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 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

[14] 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

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 (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.

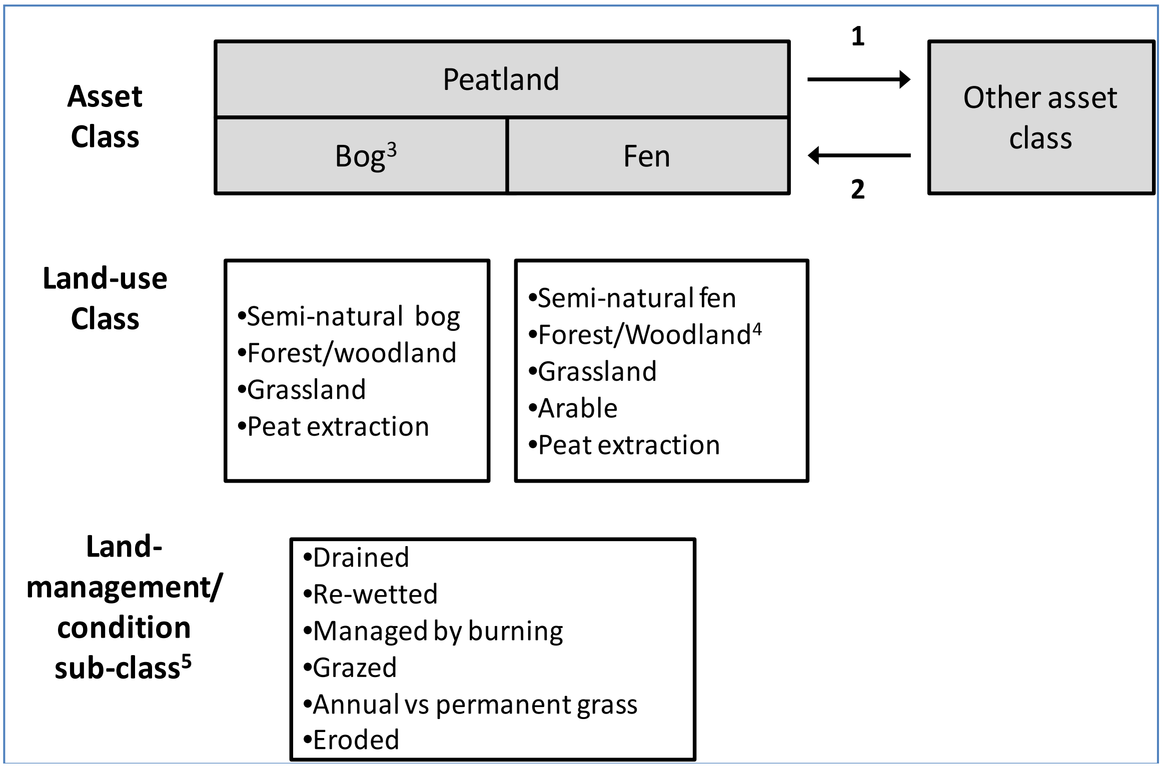
In 2013 the European Union made a decision (EU/529/2013) to move to mandatory reporting of GHG emissions and removals for Cropland Management and Grazing Land management under the Kyoto Protocol second commitment period, 2013-2020. The UK will soon decide whether to elect WDR as an additional reporting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

1.5 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 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 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.[15]
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

[15] 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.

"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.

1.6 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 are 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
- 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.

1.6.1 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[16].

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[17]. 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.

1.6.2 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[18] (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[19] 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 records some 0.8 million cubic metres of peat extracted for horticultural use in the UK in 2012[20]. (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[21]. The inventory does not use the HDC peat sales data collected from the

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[16] Although the sporting values of deer and grouse shooting can be high.
[17] 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.
[18] http://www.iea.org/media/workshops/2007/IPCC.pdf
[19] Evans et al 2014
[20] 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
[21] 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

inventory, but the reported sales of extracted peat for England and Scotland and estimated volumes/areas for NI.[22] 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.

1.6.3 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.

1.6.4 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[23]. 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[24]. Sitka spruce is the commercial tree usually planted on peatland.

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).

1.6.5 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

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[22] 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.

[23] 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.

[24] 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.

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[25].

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[26]. 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[27].
- Estimates for two water companies in the North of England that an increase in water colour of one Hazen[28] 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 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.

[25] which is why most UK water companies are presently restoring peatland catchments.
[26] 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.
[27] trihalomethanes result from the reaction of chlorine with organic matter in the water being treated, they may have health implications.
[28] Discoloration of water is measured in Hazen units (HU).

- CREW[29] identifies the following data on the value of this ES:
    - o 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[30] 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.

1.6.6 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[31] 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[32]. 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

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[29] http://www.crew.ac.uk/sites/www.crew.ac.uk/files/publications/CREW_%20Sustainable%20Land%20Management.pdf

[30] It should be noted that approximately 50% of areas in Scotland are supplied from private water supplies, not Scottish Water.

[31] 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.

[32] Birnie, R.V. and Smyth, M.A. (2013) *Case Study on developing the market for carbon storage and sequestration by peatlands.* Crichton Carbon Centre.

into CO_2[33]. 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 in overall greenhouse gas emissions in the short term[34], as indicated in the Peatland Code and illustrated in Table 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.[35]

Table 4: example of table building Emissions Factors for peatland condition, from Work Package 1 of this contract (interim report). Emission Factors were developed using data from published sources ($tCO_2eqha^{-1}yr^{-1}$) 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*
Near Natural	Mean (±StE)	3.2(1.2)	-3.0(0.7)	0.0(0.0)	0.88[1]	0	**1.08**
	Median	1.5	-2.3	0.0			
	Lower	0.6	-4.5	-0.1			
	Upper 95% Confidence Interval	5.8	-1.6	0.0			
	n						
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			
	Lower	-0.2	-4.8				
	Upper 95% Confidence Interval	2.3	4.7				
	n						
Drained	Mean (±StE)	2.0(0.8)	1.4(1.8)	0.0(0.0)	1.14[3]	0	**4.54**
	Median	1.0	-0.9	0.0			
	Lower	0.3	-2.5	-0.1			
	Upper 95% Confidence Interval	3.7	-1.9	0.1			
	n						
Actively Eroding	Mean (±StE)	0.8(0.4)	2.6(2.0)	0.0(0.0)	1.14[4]	19.3[5]	**23.84**
	Median	0.2	0.4	0.0			
	Lower	-0.2	-1.9	0.0			
	Upper 95% Confidence Interval	1.9	7.0	0.1			
	n						

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)[36]. Using these

[33] http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=2&ProjectID=17326

[34] 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

[35] 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.

[36] 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.

estimates, it is easy to estimate changes in GHG emissions as a result of changed management, including restoration; see for example Table 5 which outlines expected greenhouse gas emission savings as a result of changing management of bogs.

Table 5: example of table showing changes in greenhouse gas emissions according to change in peatland condition, from Work Package 1 of this contract (interim report). Net effect on emissions resulting from restoration and changing Condition Categories were calculated using the Emission Factors given in table 4.

Condition State Change	Net Effect (t CO_2 eq ha^{-1} yr^{-1})
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)[37] 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[38]. Yet draft work by this research team for DECC[39] 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.

[37] http://www.climatexchange.org.uk/index.php/download_file/162/194/

[38] http://www.climatexchange.org.uk/files/1913/7339/0087/Research_summary_Potential_Abatement_from_Peatland_Restoration.pdf

[39] 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.

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 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.[40]

1.6.7 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.

1.6.8 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

[40] 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).

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.

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[41], although there may be specific needs to realign footpaths, including parts of long distance routes such as the Pennine Way.

1.6.9 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[42] 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

[41] 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.
[42] https://unstats.un.org/unsd/envaccounting/seea.asp

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.

Table 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[43]	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[44]. 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	Archaeology,	May be priceless? Exclude values from the accounts at first

[43]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.

[44] *www.iucn-**uk**-peatlandprogramme.org*

Likely valuation method – willingness to pay, market prices	palaeoecology	
	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.

1.6.10 Discussion

The notes and table above 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.[45]

1.7 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.

[45] 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.

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.

1.8 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 6:

Table 6: 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[46] 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 below[47]:

[46] Suitable carbon metrics would include those published in Birnie and Smyth 2013, and developed in Work Package 1 of this contract.

[47] (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 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

1.9 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.

Annex 10 on Specific carbon issues:

The choice of values for carbon flows to be used in UK natural capital accounts are being examined further for other assets (e.g. woodland). However, there are other issues with including carbon in the account, which are briefly discussed here.

- Additionality

Additionality is used in a carbon accounting context to mean net carbon emission savings or sequestration benefits over and above those that would have arisen in the absence of a given activity (e.g. woodland existence/creation). This requires establishing a ‘business as usual’ baseline, as discussed above, which requires determining a counterfactual for identifying carbon reservoirs, emissions and sequestration/savings. There are many forms of additionality. For the purposes of carbon accounts in the context of national ecosystem asset accounting we are concerned with two forms:

- Carbon additionality.

This is the net impact on the carbon balances. The complexity of analysis associated with this depends upon the breath of carbon reservoirs taken into account in the baseline, emissions and sequestration. As set out by Valatin (2012), any focus which only considers carbon fluxes associated with above-ground vegetation is too narrow for peatlands, although it may be adequate for woodland carbon on mineral soils. For peatlands, the soil is the major carbon store, and its condition is responsible for the greatest annual flows. Therefore, account must be taken of below-ground carbon reservoirs including soils, and carbon lost from the soils through drains and rivers as Particulate Organic Carbon and Dissolved Organic Carbon.

- Reporting additionality

Reporting additionality (Valatin 2012) is the legal, regulatory and institutional aspect of additionality in the sense that carbon account must be additional to those emissions reductions reported elsewhere. This is more of a concern for the regulatory reporting of emissions by participants of mandatory government schemes (such as the EU emissions trading schemes and Carbon Reduction Commitment) because the government already reports on their emissions reductions in its climate pledges. Carbon credits from schemes such as the Woodland Carbon Code cannot be reported due to the risk of double counting. This is less of a concern for the reporting of carbon for national accounts. However, an approach to national accounting that used evidence from such carbon offset/credit schemes would have to ensure that the reporting of carbon reductions was additional.

- Displacement

Changing land use from drained to undrained might lead to reduced carbon emissions in a specific area, but land use practices might simply be displaced to another peatland location in the UK or another country. Carbon is a public good and its value is not influenced by the location of emissions/sequestration/storage.

However, displacement, particularly if resulting in more intensive production on existing areas rather than use of new areas, is highly likely to be on non-peatland soils. Its impacts should therefore be detected under other assets in the UK natural capital accounts.

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