Towards an assessment of the state of UK Peatlands
DRAFT VERSION 7.

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Note

This draft report has not yet been peer reviewed and should not be quoted in full or in part until it is formally published. This draft does not reflect the views and policy of the Joint Nature Conservation Committee and the UK conservation agencies. This has the status of an 'unpublished report.'

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Executive Summary

This report assesses the state of the UK peatlands, based on available information on the extent and location of peat soil and peatlands, vegetation, land cover, land use, management and a range of environmental influences. The report provides a comprehensive overview and estimates of extent and condition of peatlands in each of the four countries.

There is little consistent UK-wide information on peatlands (maps or statistics) as most of the research and conservation work has been conducted at a regional / country scale. Reconciling the various descriptions and classifications to provide a unified picture of the state of UK peatlands represents a significant challenge.

This review is divided into two parts. Part 1 addresses how we define, delineate and describe peatlands, and considers critically the sources of available information. It touches briefly on the likely impact of peatland management on the ecosystem services delivered by peatlands. Part 2 provides a synopsis of the state of peatlands in the four countries.

There are still insufficient data and information to provide a definitive overview of the state of the UK's peatlands resource as a whole. This report identifies the key gaps in current knowledge.

We need now to understand how we can take forward existing approaches into a fit for purpose assessment of peatlands in the UK which will contribute to ecological, conservation and economical sustainability of peatland management.

Within the limits of the information that we have available how can we address future information needs? To answer this, we need to address a range of other questions:

- What is the information to be used for? – Currently this is primarily to fulfil international (e.g. Kyoto, Convention on Biological diversity), EU, UK and country obligations, legislation and policy (climate change, renewables, biodiversity, land-use). A clear understanding of what the information is needed for helps determine what information is needed, which in turn provides a focus for the development of appropriate data-gathering methods.

- Can we make better use of existing peatland information and if so, how?

- Can new technology, particularly in the field of remote sensing improve our understanding of peatland extent, condition and trends at an acceptable cost?

- Where current information needs are not, and cannot readily be met, what are the research requirements to address data and methodological gaps?

1 Introduction

The term 'peatland' conjures immediately recognisable images. These are often characterised by vegetation, or by the visual presence of peat itself, and can include wild upland moors, bogs, fens[1] or expanses of agriculturally cultivated peat. The term is widely used among the scientific and policy communities to refer to either a soil type (peatland soils) or to join a particular set of "peatland" habitats such as bogs and fens. This report attempts to provide clear definitions relating to peatlands, or recognising where some definitions may be unhelpful, before going on to address the current state of peatland soils and habitats in the UK.

Much is known about the classification, ecology and palaeoecology of our peatlands, but recently there has been an increasing emphasis on understanding peatland function. While the former approach has underlined the intrinsic value of peatlands, our increasing understanding of peatland function is illuminating their role in delivering a broad range of ecosystem services, which comprise their social and economic value to society. However, the way that peatlands function is fundamentally affected by their condition, which itself is the product of land management, and other environmental pressures, and can often be indicated by land cover or vegetation.

This report therefore aims to describe the state of UK peatlands, using available information on peatland extent and location, vegetation and land cover, land use and management, and environmental pressures. It also reports, where possible, on the attributes of the peat material itself. Information on all these aspects of peatlands can be drawn from a wide range of different sources, which have been gathered using different approaches and for many different purposes. Reconciling the various descriptions and classifications to provide a coherent picture of the state of UK peatlands represents a significant challenge.

The report aims to provide the context to other inquiry topics, by discussing and comparing peatland classification schemes across the UK, and describing the extent, management, cover and condition of our peatlands. It cannot resolve differences in current peatland definitions, but aims to present a framework to understand the impacts of how we manage peatlands.

An understanding of the state of UK peatlands will be of value for a number of reasons. It will help us to:

- understand how our activities, under current and past policy drivers, have affected the peatland resource, for better or worse;
- relate this to information on ecosystem services to understand the scale and impact of such changes on peatland functions, understanding risks and benefits;
- use this information to identify priorities for restoration and/or management change; and
- inform policy, delivery and research activities which will address these priorities.

This review is divided into 2 parts. **Part 1** addresses how we define, delineate and describe peatlands, and considers critically the sources of available information. It also briefly describes the likely impact of peatland management on the ecosystem services that

[1] Marshes are not considered here as most mire ecologists are restricting this term to wetlands on mineral based soils

peatlands deliver. **Part 2** of this report outlines information available on the state of peatlands at national levels and concludes with a discussion on the key issues limiting our current understanding of peatlands and options to address these.

References to web pages with relevant sources of information are indicated in the text with [(x)] and are shown at the top of the reference list.

Part 1 – Peatlands - type and function, definition and data sources

2 What are peatlands in the UK context?

The Ramsar Convention (1971) proposed a definition of peatlands as:

"*ecosystems with a peat deposit that may currently support a vegetation that is peat-forming, may not, or may lack vegetation entirely. Peat is dead and partially decomposed plant remains that have accumulated in situ under waterlogged conditions"*

The Convention defines active peatland as areas where peat is currently forming and accumulating but also includes inactive peatlands that no longer accumulate peat. Inclusion of the latter category is vital because inactive peatlands respond to management and environmental pressures to deliver both ecosystem services, such as food or timber, or generate problems such as greenhouse gas emissions or discoloured water. Currently inactive peatlands are widespread in the UK, but the historical record contained in peat show may go through active and inactive during their development. Favourable management can result in resumed peat growth.

There are some points to note on using the Ramsar Convention definition.

- Peat-forming vegetation can occur over organic deposits that may be too thin to be defined as peat based on conventional pedological criteria. It is proposed here that the presence of peat-forming bog vegetation, irrespective of the depth of the underlying organic layer (see section 4.1.1) is also useful in indicating the location of peatlands. Some types of peat-forming fen vegetation can also occur on mineral substrate (e.g. reedbeds in estuarine sediment), and so have not been used to indicated peatland;

- This definition would exclude peatlands where a known peat deposit has been lost as a result of human influence (e.g. peat extraction, human-induced peatslides, wildfire, severe erosion exacerbated by overgrazing, pollution, burning, or agricultural wastage of peat). Under restoration management, these areas may be suitable for peat formation in the future. While these may no longer be true 'peatlands', they represent both historic and potential future peatlands, and should be included and assessed when considering the state of the UK's peatlands;

- Not all peaty deposits are present on the surface of the soil. Some peaty deposits are overlain by mineral deposits such as marine or alluvial sediment, or deposits of tufa from calcareous springs, and peat may 'outcrop' occasionally at the surface. These buried peats are important carbon stores, store historic environment information and continue to influence hydrology. For this reason they should be included in the broad definition of peatlands but may present few or no opportunities to recreate peat forming habitats.

2.1 Peat and Peat Formation

Peat is defined as the partially decomposed remains of plants and soil organisms which have accumulated at the surface of the soil profile. Peat accumulates where the input of organic material from the surface exceeds the ability of soil organisms to 'turn-over' the new material added from the surface. Under UK climate conditions, this happens under seasonal or year-round water-logging and is exacerbated by cold temperatures.

Because of the very low mineral fraction in peat materials, they are much less dense than any other soil materials, with most of their volume being occupied by water when wet. The organic matter fraction in peat material is very high and varies from anything above 20-25% organic matter for 'peaty' soil, to more than 50-60% organic matter for 'peat'. Soil with peat layers typically have dry bulk densities ranging from between 0.06 g cm^{-3} to 0.4 g cm^{-3}

depending on the level of humification, compaction or mineral content. Lindsay (2010) has reported that, in the UK, the typical peat organic material contains around 52% carbon by dry weight.

The range of organic compounds that form during decomposition of living organisms makes peat a material with some unique characteristics. When peat becomes very dry, it can form a water-repellent barrier making the peat difficult to rewet and prone to erosion by wind and water. If peat ceases to be waterlogged, decomposition is no longer retarded and the peat gradually decomposes to become, eventually replaced by a mineral soil. This process results in the release of greenhouse gases to the atmosphere, and dissolved organic carbon to adjacent streams and water bodies – both of which represent significant environmental concerns.

The waterlogging that encourages peat formation can result from high precipitation and poor drainage, or where there is a more or less constant supply of ground water and/or surface runoff, in basins, floodplains or springs.

The origin and quality of the water supply are important determinants of the broad type of peatland that develops. Those which received all their water from precipitation are **bog peatlands**. Where such peat forms across an upland hilly landscape, it is known as a **blanket bog** peatland. In lowlands such bogs can form on wet floodplains or on the surface of existing fen peats where they rise up above the surrounding landscape and are known as **raised bogs**. Those which formed under the influence of groundwater are **fen peatlands**. A peatland landscape can display a complex combination of these types; upland blanket bogs are often interspersed with nutrient poor fens, and raised bogs can form over fen peatlands, and drain into fringing 'lagg' fens.

The types of plant forming the peat vegetation strongly influence the peat soil properties. Peat soils formed from bog mosses is often reddish-brown and fibrous. Reed or sedge peat can vary from fibrous to well humified, while peat formed from purple moor-grass tends to be well humified black material. Though all peat retains water, bog moss peat retains more because the moss's cells are adapted to store water. Waterlogging coupled with the importance of rainfall as the dominant water source for many of our peatlands generally results in nutrient poor soils.

Active bog peatlands have been described as two-layered structures (Ingram 1983; Clymo 1992). The lower layer, which is almost continually waterlogged is known as the catotelm and represents older peat material. The layer above the typical lowest water table is called the acrotelm. This layer contains newer plant material and includes any living mat of mosses present. Bog surfaces can be patterned with mosaics of pools, hummocks, ridges and lawns. Lindsay (1995; 2010) provides a comprehensive description of the functional units of bogs and describes different types of bogs.

The extent to which this two-layered model applies to fens is much less clear, though it probably applies quite well to many 'bog-like' poor fens. Fen peatlands may take the form of infilled water bodies, floating mats of vegetation and wetlands associated with springs. Because of their topography, floodplain fens may receive deposits of alluvial or marine mineral sediment generating a banded structure of peat and mineral layers. McBride et al (2010) provides descriptions of fen flora, fauna and hydrology, while the much more detailed Wetland Framework project (Wheeler et al 2009) provides an exhaustive account of the varied water supply mechanisms which operate across fens in England and Wales.

2.2 Defining peatland – the different approaches

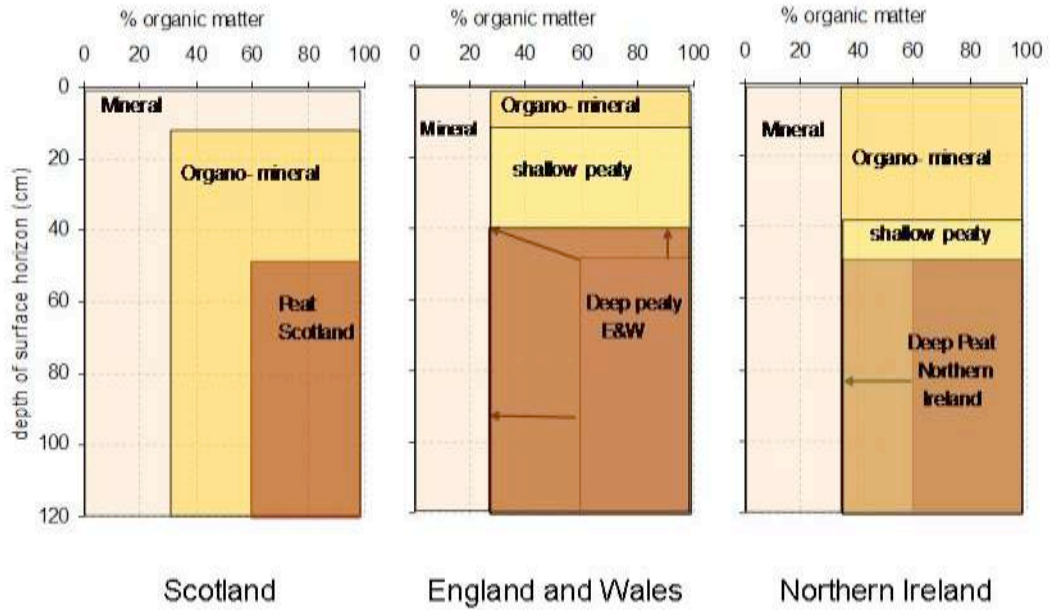
The Ramsar definition of peatlands is internationally accepted, but assessment of peatland extent in the UK pre-dated the Ramsar definition and there are key differences in the approaches that have been historically used in UK to define and delineate the peatlands. Across the UK, definitions of peatlands have been based on soil and geological description and definition, or inferred from information on vegetation description and hydrological processes. Understanding how these different features were and are defined and recorded has implications for any assessment of extend and state of peatlands.

2.2.1 Soil-based definition of peatlands

Peatlands have been defined by the presence of peat or peaty soil types. Soils have been studied and mapped in the UK since the early 1940s by the National Soil Survey Institutes of England and Wales, Scotland and Northern Ireland. In each country, the national survey institutes sought to adapt existing classification systems for the range of soils they encountered. All soil classification systems used in the UK evolved from the Avery soil classification (1980) and are based on the field observation of individual soil profiles and the recognition of their texture and morphological characteristics, in particular the nature and sequence of soil layers or horizons. The identification of a specific soil type does not depend on any horizon achieving a specific thickness, except in the case of peaty and peaty soil types where both the depth of peaty material and the organic matter content of that material are used as identification criteria.

Different thresholds have been applied to these factors to identify peat soils, as summarised in Figure 1. The concept of deep and shallow peaty soil which has been extensively used by the 2010 Defra 'Peat Partnership project' [(x)] but different thresholds apply across the UK. For Scotland deep peaty will be equivalent to peat soil and shallow peaty to organo-mineral soils. The term 'shallow peaty-soils' used in this report refers to shallow peaty soils in England, Wales and Northern Ireland and organo-mineral soils in Scotland.

Figure 1. Minimum depth and % organic matter content threshold used for differentiation between mineral, peaty (organo-mineral) and peat soil in Scotland, England and Wales, Northern Ireland soil classification and in the British Geological Survey (BGS) superficial geological material classification.



Recent work towards a harmonised international standard in soil classifications has led to the development of the World Reference base soil classification [(x)]. This system is now in used by EU institutions for reporting on soil conditions and has been used to derived 1:1 000 000 soil and risk maps in Europe. It identifies soil by the presence of diagnostic horizons but does not record depth of peat layer. There is some correlation between 'histosol' type (characterised by more than 40 cm of peat with more the 20-30% soil organic content) and the UK deep peat concept but no clear link between other WRB soil types and UK peaty soil classes. Since depth of surface horizon and organic matter content are clearly key parameters in all peatland definitions, future soil surveys that aim to record the location of peatlands should ensure that both these factors are adequately addressed, to enable the fullest cross-compatibility with current approaches.

2.2.2 Vegetation-based definition of peatlands

The presence of peat-forming vegetation, dominated by species adapted to the waterlogged and generally nutrient-poor conditions, is a useful indicator of active peatland. It should be noted that the definition of peatlands also includes areas that are bare or supporting vegetation that currently does not form new peat deposits.

Surveys of peat-forming vegetation are undertaken for biodiversity purposes and not specifically for determining the extent or condition of peatlands. However, where soil surveys are based on information from soil pits and auger samples, the extent of soil types between these sites is often inferred using a combination of topography and vegetation cover.

The absence of peat-forming vegetation does not mean that peat itself is absent, and unless soil information is available it may be hard to recognise true peatlands. Furthermore, some vegetation associated with deep peat is also found on shallower peaty deposits (such as blanket bog vegetation over shallow peat) or even over mineral soils (such as reedbeds in estuaries). A full description of different vegetation found on peatlands is given in section 4.1.

This extended definition includes bog vegetation over 'shallow peaty' soils, which means that maps showing this vegetation type can be used to identify peatlands. However, the presence of peat forming, semi-natural vegetation, or even any vegetation at all, should not be used to indicate on its own the full extent of peatlands.

2.2.3 Geological-based and ecological definitions of peatlands

Because of the timescale involved in the formation of deep peat (over 1000's of years), some peatland areas are also identified as Quaternary geological deposits. Since the late 19th century, the survey of superficial geological deposits in the UK recognised the occurrence of peat deposits extending to >1m below the ground surface, among other Quaternary superficial geological features (McMillan and Powell 1999) Extensive areas of peat have formed since the end of the last glaciation (around 10 000 years BP) during the Holocene stage; peat is also present as interbeds or 'pocket peat' within earlier deposits. The superficial geology mapping was intended to show material underlying the modern soil profile, and so BGS mapping does not map peat deposits that occur entirely within 1 metre of the ground surface, and therefore only shows deeper deposits or buried peat.

Peatlands have also been defined as an ecological construct, which consider together vegetation, morphological and hydrological characteristic to define the range of functioning peatlands (Lindsay,1995, 2010). Bog peat depth can be modelled in relation to climate and topography with some success for undisturbed peatlands, and, while this fails to recognise the impacts of land management on peat depth (and more hydrological information is required to model fen peat location), such approaches may be useful in indicating where

different depths of peaty material would be expected to accumulate. Such a model was developed for the ECOSSE project (Scottish Executive 2007), and tested against field measurements for peatlands in Wales and Scotland.

The hydrology of soil type classification (HOST) (Boorman et al 1995) can also be used to define the range of peatland. However the HOST classification is based on the physical properties of the soils and their effects on the storage and transmission of soil water and does not include any consideration of vegetation cover. The presence of peaty surface layers (defined as having more than 20% of organic matter) is one of soil properties used in the HOST classification.

3 Sources of data on peatland location

There is a wide range of sources that are useful in different ways to characterise peatlands in the UK and to infer information on their location and states. These include:

- National surveys of peat, soil or vegetation; most of those were conducted to provide information for mapping of UK resources;
- Maps of soil, vegetation, geology and other environmental functions (e.g. HOST classification system);
- Research and manipulation experimental sites; these provide information on the processes and dynamics of change in peatland ecosystems; and
- Soils, biodiversity and environment monitoring schemes; provide information on trends in state of peatland interest but are often point-based and cannot be used to map extent of peatland.

In recent years, many soil research activities have been driven by the policy requirements to understand and quantify the state and functions of UK soils and their responses to climate and environmental changes. There has been a strong focus on organic-rich soils and such work provides a valuable insight on the current state of peat in the UK, for example, the ECOSSE project to refine our understanding of peat soil in Scotland and Wales (Scottish Executive 2007), the Scottish Government expert workshop to establish the current state of knowledge of and future evidence needs for the extent and condition of carbon stocks in Scottish peatlands (Chapman et al 2009) and the Defra Peat Partnership programme [(x)], NERC EA-QUEST programme looking at climate change impacts in the uplands [(x)].

This section describes the approaches used in these soils and geological data sources on peatland location, while descriptions of mapping of peatland vegetation , management and function are given in section 4.1.

3.1 Peat survey, databases and point sources information

Peat surveys

Information on the location, extent and depth of individual peatland bodies or on transects across the landscapes have been recorded since the mid 20th century as part of the development of national soil surveys discussed below and also for the purpose of assessing the value of commercial exploitation of peatland in the UK (supporting commercial peat extraction or more recently development of renewable energy developments).

In Scotland, peat surveys were conducted in the 1940s and 1950s for the Scottish Peat Committee (Scottish Peat,1962). The information was later reviewed in 1990 and a peatland database compiled (Birnie and Ward 1991). Together with data from the peat survey maps, commercial extraction surveys and Forestry Commission site survey reports; this information was geo-referenced in the NSIS database.

In England and Wales, an intensive survey of lowland peat was carried out by the Soil Survey of England and Wales (Burton and Hodgson 1997). This recorded detailed transect and grid-based information on peat depth and quality, but little of this data has been digitised.

The National Peat Resources Inventory (NPRI) is a geo-database of lowland peatland information based on surveys by Lindsay and Immirzi (1996) and by Wheeler and Shaw in FenBase and BogBase (Shaw and Wheeler 1995; Shaw and Wheeler 1997; Money and Wheeler 1995; Shaw et al 1998). The NPRI cover the whole extent of deep peat within Britain (not the UK). It include land-cover information for lowland raised bogs (and detailed land cover maps for Scotland). Most sites include digitised mapped boundaries, although some are still represented by circles of the same area as the feature.

In Northern Ireland, historic peatland extents are available through the drift mapping of the Geological Survey, although Cruickshank and Tomlinson (1988) indicate that the original 19th century field sheets can be inconsistent in the recoding of peat occurrence. The larger peat bodies have been surveyed in terms of peat depth and quality, initially with a view to exploitation (Double 1954) and latterly with a view to conservation (Grant et al 1997). The most comprehensive assessment of peat distribution is the Northern Ireland Peatland Survey (Cruickshank and Tomlinson 1988). Here, peatland extent was interpreted (in terms of erosion, vegetation cover etc) from the then most recent aerial photographs and mapped onto 1:10,000 sheets and subsequently digitized.

National soil database

The National Soil Inventories for Scotland and for England and Wales also recorded a range of chemical, physical and contextual information to inform on the properties and state of the soils at the time of sampling on a 5km grid based on the National Grid of GB. This inventory was established in the 1980s to support the development of the 1:250 000 soil surveys. A partial resampling of this original inventory was done over the last few years, providing some information on change in soil and soil carbon in the UK (Bradley et al 2005; Chapman et al 2009). Similarly in Northern Ireland, 5km grid samples were taken during the life of the survey (1988-97), with resampling occurring in 2004/5.

Ad hoc soil and peat mapping

Soil and peat mapping produced for Environmental Impact Assessments for planning applications also represent a significant new source of data on peatland but is not easily publically accessible. For some sites, however, it will be available on the relevant UK local authority planning websites.

Remote sensing techniques including LiDAR and satellite survey have been used in recent years to assess the extent and state of peatland vegetation (Evans et al 2005) and soil features (Scottish Government 2009a, 2009b). Outcomes of these surveys have been used to revise estimates of peatland extents and conditions.

3.2 Map and country wide information

Soil types change over short distances reflecting the complex interaction between soil parent material, landform, climate, vegetation and past land use. Furthermore, some areas are more variable than others. Soil maps aim to delineate areas where the soil profiles are relatively similar, but extensive and detailed survey is not always a practical option for large-scale mapping of soils and will be constrained by a range of methodological factors. These have given rise to different methods to represent similar information in the various UK countries.

Many of the UK's peatlands are complex mosaics of wetland habitats, have gradual transitions between soil types, are remote, may not reflect the underlying geology, and are agriculturally of lesser importance than most mineral soils. This means that most UK peatlands are less likely to have been intensively surveyed and mapped at larger scales, and

soil maps are therefore more prone to inaccuracies. Even where more detailed mapping is available in paper maps, these have been scaled up to 1:250,000 scale in readily available digitised versions. Peatland units mapped at this scale are therefore likely to encompass a variety of peaty and non-peaty soils. This heterogeneity is problematic in terms of assessing the extent to which peatlands deliver certain ecosystem services.

The following sections briefly outline the approaches taken to map soils in the countries of the UK, and Table 1 outlines some of the key differences between UK soil mapping systems.

3.2.1 Soil Maps

The typological classification adopted for all UK soils is based on the description of the vertical arrangement of soil layers or 'soil profile'. As described in section 2.2.1, the thresholds to characterise peat and peaty horizons are different between countries. Based on profile description only, 10 major soil groups are recognised in the UK which are divided into 45 soil groups and 116 soil sub-groups to form the basis of soil classification (Avery 1980).

Different soil classification systems for the mapping and representation of soils have been adopted from across the UK by the Soil Survey of Scotland (now Macaulay Institute - MLURI), the Soil Survey of England and Wales (now National Soil Resources Institute - NSRI). The Northern Ireland Soil Survey (now Agri-Food and Biosciences Institute -AFBNI) has developed a modified version of the England & Wales soil mapping classification (Cruickshank 1997).

The most detailed level of differentiation in this system groups soil profiles developed under similar conditions and similar parental materials. These are called 'soil series' in England, Wales and Northern Ireland and 'soil association' in Scotland and form the primary units of classification and mapping. They represent several thousand individual soil types across the UK.

Mapping at high resolution (<1:50,000) is able to represent individual soil series and is broadly comparable between the countries. For small scale mapping (e.g. 1:250,000) and thematic mapping (e.g. Soilscape map in England), different mapping strategies and approaches to aggregation of soil series have been adopted in each country.

Table 1 shows the equivalence between peat and peaty soils classes in the different systems adopted by UK soil surveys. The soil survey data collected has been re-interpreted by various projects to attempt to delineate peatlands of different types. The soil classification for England was used in the Partnership Peat project.

Table 1. Peat and peaty soil classes as defined in the UK soil classification systems.

Soil types	England	Wales	Northern Ireland	Scotland
Deep Peaty Soils / Peat	E&W soil classification Soil Association Longmoss, Crowdy 1 and 2 Winter Hill; Turbary Moor, Adventurer's 1, 2 and 3; Altcar 1 and 2; Mendham; Peacock; Clayhythe; Ireton; Downholland 1, 2 and 3; Isleham2	E&W soil classification Soil Assocation Crowdy 1 and 2 Adventurer's; Altcar	Nothern Ireland classification Soil Assocation Deep Peat (>0.5m) Undifferentiated Lowland basin peat and Blanket peat	Scotland soil Classification Soil Map Unit 3 Basin Peat (>0.5m) 4 Undifferentiated Blanket Peat (>0.5m) 603 Eroded Basin Peat (>0.5m) 604 Deep Blanket Peat (>1m) 605 Eroded Deep Blanket Peat (>1m) 606 Eroded Undifferentiated Blanket Peat (>0.5m)
Shallow Peaty Soils / Organo mineral soils	E&W soil classification Soil types: Humic Rankers, Stagnopodzols, cambic stagnohumic gley soils. Soil associations: Revidge, Skiddaw, Bangor, Belmont, Hexworthy, Earle, Maw, Hafren, Lydcott, Gelligaer, Princetown, Onecote, Wilcocks 1 and 2, Wenallt.	E&W soil classification Soil types: Humic Gley soils; Humic Rankers; Podzols; Stagnohumic Gley Soils; Stagno-podzols	NI soil classification Soil types Humic rankers; Peaty Podzols; Surfacewater Humic gleys; Shallow Peat	Scotland soil Classification MSSG Humus-iron podzol (uncultivated), peaty podzol, subalpine podzol, alpine podzol, peaty gley, humic gley, peaty ranker (including podzolic ranker), peaty lithosol, peaty alluvium
Soils with Peaty Pockets (non peaty soils or shallow organic	E&W soil classification Soil associations*: Wetton 2, Willingham, Malham 1, Midelney, Isleham 1, Laployd, Hense, Hanworth, Ireton	Not mapped	NI soil classification Soil types Organic Alluvium; Humic Gleys ; Rock Rankers	Scotland soil Classification Soil types Peaty alluvial ; Humic gley;

*In England buried peat which outcrops occasionally has been mapped 'peaty pockets' soils

i Soil map of Scotland

The Soil Survey of Scotland developed the classification and soil mapping systems for Scotland (Soil Survey of Scotland 1984) for the production of the 1:250,000 soil map of

Scotland [(x)]. The 10 class Avery System is reduced to 5 'Divisions', 12 'Major Soil Groups' (MSG) and 37 'Major Soil Subgroups' (MSSG).

Areas characterised by different combinations of one or more MSSGs from the same soil associations have been grouped to give 580 Soil Map Units, which are published on the 1:250,000 soil map of Scotland. The Soil Map units are broadly equivalent to Soil Associations in England and Wales.

Information on the characteristic of soil in Scotland can be accessed via the Soil Indicators For Scottish Soils (SIFSS) web link [(x)].

ii Soil map of England and Wales

The system of soil classification and mapping in England and Wales was developed by the Soil Survey of England and Wales (Avery 1980). The most detailed level of classification in this system is the Soil Series, and some areas of agriculturally important peatlands have been mapped to series level, at 1:63,630 scale.

Areas with a similar combination of Soil Series are mapped as Soil Associations, and mapping at this level is available digitally from NSRI as the 1:250,000 National Soil Map association (NATMAP). This shows the extent of 297 soil associations across England and Wales.

Information on soil associations has been further aggregated to the level of the 'Soilscape'. There are 27 Soilscape types covering England and Wales, available through the NSRI's web server [(x)].

iii Soil map of Northern Ireland

The soil classification system used in Northern Ireland (Cruickshank, 1997) is adapted from the England and Wales classification as defined in Avery (1980). It identifies 308 distinct Soil Series, developed over 97 distinct types of soil parental material. It recognised 7 major soil groups: rankers, Brown earth, Podzols, Gleys SWG1/G1, Gleys SWG2/G2, Gleys SWG2/G2 and Peat > 50cm. Soil mapping across the whole of Northern Ireland was conducted at a finer scale (1:50,000) and is therefore more likely to show units of homogeneous peat.

3.2.2 Geological mapping

The classification scheme for geological mapping was developed by BGS for natural superficial deposits of Quaternary age (traditionally described as 'drift') to provide UK-wide 1:10000 scale maps. The classification scheme identifies a broad class of 'organic deposits' which is divided into 'biological deposits' and 'peat deposits'. The latter is subdivided into 6 sub-categories for more detailed mapping (basin peat, hill peat, blanket bog peat, fen peat, raised bog peat and peat flow). This terminology emphasises the geographical setting, topography and drainage conditions as well as the origin of the peat-forming vegetation. The superficial geology mapping was intended to show material underlying the modern soil profile, and so BGS mapping does not include peat deposits that occur entirely within 1 metre of the ground surface, and therefore only shows deeper deposits or buried peat (McMillan and Powell 1999). The 1:625,000 scale UK geology map is freely available for download from the BGS website (http://www.bgs.ac.uk/products/digitalmaps/digmapgb_625.html). The map of 'peat deposit' is not a proxy for peatland extent and shows an underestimation of the extent of UK peatlands (e.g. in the western parts of Counties Fermanagh and Tyrone).

3.2.3 Vegetation maps

Mapping of peatland vegetation cover is provided by either remote sensing or more local scale surveys of the detailed botanical features. The main information sources are given in Appendix 1.

The Landcover Map 2000 (CEH) (x) uses remote sensing data and ground-based survey information to classify land into 26 broad categories based on the UK Biodiversity Action Plan broad habitats. Where land is enclosed, data from within each land parcel was collated and analysed, to give a relatively good accuracy of interpretation. However, in upland and unenclosed areas, the division of land into vegetation types was difficult and the accuracy of the map is lower. This problem is more acute in Scotland and as a result, LCM 2000 has not been used for mapping peatland habitats in Scotland . A new land cover map is currently being produced which aims to improve upon the accuracy of the 2000 map, and report on major changes in land cover.

The Land Cover Scotland (LCS88) (x) is the first census of vegetation, produced between 1987-89. It used the interpretation of medium-scale air photograph covering the whole of Scotland to report on 127 different land cover types. Data were ground validated. Information provide by LCS88 is deemed more accurate than LCM 2000, though it is now dated and there are plans for it to be repeated. LCS88 is available under licence from MLURI.

In England, BAP inventory mapping of blanket bog habitat was used to identify peatlands outside areas mapped by soils or geological mapping (Natural England 2010b). In Wales, UK BAP Priority Habitats have been mapped following Phase 1 survey (Blackstock 2010). At present there are no maps available of peatland Priority Habitats in Scotland.

The country conservation agencies hold survey information on peatland vegetation from surveys undertaken when designating SSSI/ASSIs (Sites/Areas of Scientific Special Interest) and SACs (Special Areas of Conservation) (x). Most of the surveys have been digitised..

4 Peatland vegetation, land use, peat functions and environmental pressures

As well as knowing the location, extent, depth and origin of peatlands, it is also important to understand the external factors that affect how peatlands function. Many of the functions of a peatland are influenced by its vegetation, land cover, and land management, as well as, environmental pressures, and the condition of the peat itself (for example its state of decomposition or severity of erosion). Considering these factors together, it is possible to derive a wide variety of information relevant to policy and environmental management, such as current likely carbon loss, GHG flux, costs of restoration, and also to identify likely stakeholders in policy development and land management.

The following sections describe the range of land cover, land management, environmental pressures and functions relating to peatlands. They include a review of available data sources across the UK peatlands.

4.1 Peatland vegetation and land cover types

All UK peatlands have formed under peat-forming vegetation, but a wide range of other vegetation types occur over peatlands as a result of land management. A full description of the land management that affect peatlands is presented in section 4.2 This section describes the range of vegetation typically associated with active and inactive, or otherwise degraded, peatlands and defines these with reference to some of the common vegetation communities described in the National Vegetation Classification (NVC) system (Rodwell 1991a, 1991b, 1992, 1995). Further information about the NVC is also available online from the JNCC website [(x)].

Other available information on peatland vegetation and land cover is from large-scale mapping information (often derived from remote sensing) or sample-based surveys. These are augmented by more local scale, detailed vegetation surveys.

Sources of information on vegetation and land cover relating to peatlands are given in Appendix 1 with detailed data sources indicating peatland vegetation and land cover.

4.1.1 Peat-forming vegetation

A suite of vegetation types are associated with wet conditions that are conducive to peat formation, and represent peatlands in their most active, and least damaged state. Most UK peatlands are bog peatlands, receiving all their water from precipitation, and these have a characteristic range of **bog** vegetation, which is similar for both blanket bogs and raised bogs (NVC classes M17-M20). The restricted diversity of bog vegetation reflects the harsh environment, which is fed by rain water naturally poor in nutrients. Vegetation in this situation is slow-growing and often dominated by bog mosses (*Sphagnum spp.*) or cotton-grasses (*Eriophorum spp.*), with dwarf shrubs including common heather (*Calluna vulgaris*) and cross-leaved heath (*Erica tetralix*), and grasses such as purple moor-grass (*Molinia caerulea*).

The type and productivity of **fen** vegetation reflects the relative influence of plant macro-nutrients (notably ~N, P and K), base cations and pH. So-called 'rich-fen vegetation' (including M9, M13, M14, M22, M24, S1, S2, S24, S27) develops at locations subject to the influence of calcareous but nutrient-poor water and its distribution is strongly correlated with outcrops of calcareous bedrock or drift. The vegetation is often species-rich and commonly includes a significant brown-moss element, with an over-storey of forbs and a wide range of

graminoids. More productive swamp and tall-herb fen vegetation, dominated by common reed (*Phragmites australis*) and other tall graminoids develop at locations with relatively enriched substrates, including periodically inundated floodplains. Nutrient-poor, acidic water promotes a bog-like **poor fen** (M4- M12, M21) vegetation of bog mosses, sedges (*Carex spp.*), cotton-grass and dwarf shrubs (McBride *et al* (2010) Many examples of poor fen occur as soligenous features (flushes and springs), often in association with bog or marshy grassland vegetation. **Wet woodland** habitats (W1-W7) are part of the natural succession process in fens, and many (possibly most) fens have layers of woody peat showing how woodland was part of fen landscapes periodically in the past.

Bog and fen vegetation types are recognised under the EC Habitats Directive as Annex 1 habitats (Council of the European Communities 1992) and as UK Biodiversity Action Plan (2010) Priority Habitats (Blanket bog; Raised bog; Lowland fens; Upland flushes, fens and swamps).

Purple moor-grass (*Molinia caerulea*) is a deciduous grass and a natural component of bog and poor fen vegetation. Under certain drainage and burning management, such peatlands can become almost completely dominated by this species (M25). The annual build up of purple moor-grass litter does form peat, especially where it accumulates in pools, and it does appear as sub-fossil remains in the palaeoecological record. However, the extent to which purple moor-grass-dominated vegetation are important in ongoing peat formation is not known.

Wet heath vegetation (M15, M16) is dominated by cross-leaved heath, deer-grass and bog moss. This is most widespread on shallow peaty soils which often originate from partial drainage, burning and peat-cutting.

Bog woodland (W18/M19, W2b, W4c) comprises rare vegetation types. The structure and function of this habitat type is finely balanced between tree growth and bog development.

4.1.2 Other peatland vegetation types and land cover

Other types of semi-natural vegetation which are not associated with the formation of waterlogged peat can also occur over peaty soils as a result of management and environmental impacts.

On blanket bog and shallow peatlands, drainage, rotational burning, grazing and air pollution can be responsible for the development of **dry heathland** vegetation (H1, H8-H10, H12) dominated by common heather (*Calluna vulgaris*). This vegetation is more usually associated with the formation of thinner organic soils in freely draining areas, and is unlikely to form deep peat under our current climate. Where there is heavier grazing, often alongside drainage, **acid grasslands** (U2-U6) can develop over peatlands, dominated by mat-grass (*Nardus stricta*), heath-rush (*Juncus squarrosus*), or bents (*Agrostis spp.*) and fescues (*Festuca spp.*). These vegetation types are also more commonly associated with thinner organic or acid brown earth soils. Drainage and fertiliser application in lowland peatlands can result in **semi-natural grasslands** (MG4, MG8-MG13, M22). Other semi-natural, non-peat forming vegetation that can occur on drained peatlands includes **bracken** (U20, W25), **scrub** (W21-W24) and dry **woodland**.

Following wildfires, erosion or severe overgrazing, upland peat can be left completely without vegetation. The surface of bare peat can rapidly dry out and become hydrophobic, and the dry peat particles are susceptible to erosion, which can expose the mineral material which underlies the peat. Eroded peat may be redeposited in basins, where its flat or cracked surface can be colonised by common cotton-grass (*Eriophorum angustifolium*), which helps to trap more eroded peat. Some upland peat erosion complexes may be natural long-

standing features, but many are the product of adverse past management and/or atmospheric deposition of pollutants.

As well as changing the character of semi-natural vegetation, land management can also establish completely artificial vegetation on peatlands. Drainage, and cultivation or harrowing followed by reseeding and applications of fertiliser and lime, can create agriculturally **improved grasslands** dominated by sown forage species such as perennial rye-grass or white clover (MG7). In lowland peatlands, increased drainage and intensity of agricultural use enables cultivation for cereals, field vegetables, or root crops (No NVC classes). This also leaves the peat surface bare for periods of the year.

Forestry planting on peatlands usually results in a cover of coniferous trees, although fragments of original bog vegetation may survive in scattered open areas. In the UK the main species planted are sitka spruce (*Abies sitchesis*), douglas fir (*Pseudotsuga menziesii*) hybrid larch (*Larix x eurolepis*), and a variety of other non-native species. The native scots pine (*Pinus sylvestris*) is also planted for forestry, but occurs naturally in areas of the Scottish Highlands.

Bare peat is also a dominant land cover during peat extraction, but is normally replaced by another land cover once extraction ceases. This can include agricultural crops or forestry, but commonly peat cuttings are flooded, resulting in areas of open water. These can accumulate sediment and develop a fringing or floating peat forming fen vegetation. However, for restoration of bog vegetation, water needs to be kept very shallow, still, acidic and nutrient poor, and the influence of ground water excluded.

Some peatlands have been built over with buildings, roads or other infrastructure, while others may have been removed for quarrying of the mineral resources beneath. Quarry land cover can be water, land restored to other purposes or bare rock. However, limits to mapping accuracy can mean that larger areas of natural bare rock (e.g. scree, crags, tors) can be included within mapped peatland units.

4.2 Peat Function and External Environmental Pressures

Besides supporting different vegetation or land cover, and being subject to a range of different types of land use and management, peatlands can also be described in terms of how the peat functions. This includes reflecting the extent of erosion or decomposition of the peat itself and the behaviour of the water table. Lindsay and Immirzi (1996) provide a description of different states of degradation of bogs. A simplified version of this system, recognising five categories of bog peat function (active, degraded, bare, archaic and wasted/lost), is summarised in Table 2 , defined as follow:

- **active peatlands** characterise a functioning landscape with peat forming vegetation over healthy peat soil;
- **bare peat** has all its vegetation removed (e.g. by erosion) but has not been affected by change of land use, but contrasts with an **archaic peat** which may still have significant soil peat depth but is under other land use (forestry, cultivation);
- **wasted peat** has both lost its peat-forming vegetation and significant depth of peat soil;
- All intermediate stages between active and bare peat are described as **degraded peat**.

The location and extent of peatlands falling into the categories above are normally inferred from land management or vegetation information. Agriculturally wasted peatlands are thought mainly to occur in England, and can be indicated by the extent of a suite of soil types identified in the National Soils Map of England. However, extensive examples also occur in Wales.

In addition to the above framework, it is possible to recognise other important features of peatlands, in particular the pattern by which a degraded or bare peatland erodes.

Gullies are fluvial erosion channels which cut into a peat mass, resulting in the loss of peat transported away by water. They are naturally occurring features of peatlands, and occur where blanket peats spread to the heads of valleys. However, they also occur where artificial drainage features become eroded, and where other pressures such as wildfire, overgrazing or pollution reduce vegetation cover and exacerbate erosion. As gullies erode and branch, adjoining gullies can meet. This does result in isolated 'islands' of peat called 'haggs'. Severe erosion of this type results in a mixture of degraded or bare peat. It can also result in the redeposition of eroded peat into secondary peatlands, which capture peat material and may start to form new peat again in situ.

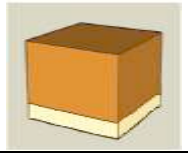
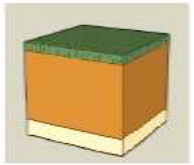
Several sources of data are available to indicate the extent of hagging and gullying, including an aerial photo survey of English Upland Peatlands (Longden 2009), the Northern Ireland Peatlands Survey, and the Scottish Peat Soils Map. The Peatland Partnership project [(X)] also provides information on extent of areas of hagged or gullied peatlands.

Peatlands are also subject to anthropogenic environmental pressures such as pollutants or the effects of climate change. Fen peatlands are affected by pollution of groundwater, particularly by plant macro-nutrients from agricultural fertilisers or domestic or industrial waste. Rain-fed peatlands are affected by atmospheric deposition of pollutants. Deposition of nitrogen (as ammonia or nitric acid from nitrogen oxides) is an ongoing problem, but during the last two centuries peatlands have also been subject to deposition of sulphuric acid rain from fossil fuel burning, soot particles and heavy metals from transport, industry and warfare.

The 'critical loads' of some pollutants, above which habitats are damaged, have been calculated following the Berne Convention. The deposition of ammonia and other pollutants is monitored under a national scheme (CEH 2008). National modelling (NEGTAP 2001) suggests that many of our peatlands are subject to critical load exceedance as shown in the UK Air Pollution Information System (APIS) [(x)].

Climate change is one of the greatest threats facing our peatlands. A recent study (Clarke et al 2010) examined the current topographic and climatic conditions in the areas where upland peats occur in the UK. This study noted that, under the most recent climate change projections, these conditions would be found to cover a more restricted area in 50 or 100 years time. This does not necessarily mean that peat will not survive in the future. Bog mosses have a much wider tolerance of climatic conditions than those projected in this study, and the essential factor in peat formation – the ability to retain water – cannot easily be modelled using this sort of approach. However, it does indicate that peatlands in the future will be under greater climatic pressure than they are currently. The best adaptive response to climate change is to secure favourable management and ultimately condition for the peatland resource – this also offers the best and most efficient route for retaining their ecosystem functions.

Table 2. Categories of peat, based on function, and their relation to vegetation management, water table and organic matter dynamics. Based on Lindsay and Immirzi (1996) and Lindsay (pers comm.).

Peat Category	Structure, Vegetation and Management	Water table	Organic matter dynamics
Active Mire 	• Semi-natural vegetation cover of bog mosses, cotton grasses and dwarf shrubs (bogs, poor-fens) and medium-tall graminoids, forbs and hypnoid mosses (other fens). • Might include Purple moor-grass dominated vegetation in some circumstances. • Diplotelmic structure in case of bogs and some fens, with true acrotelm of living bog mosses and/or recently deposited plant litter • Sympathetically managed and restored mires.	• Water table mostly fluctuates within acrotelm rooting zone. • Catotelm /deeper peat remains more or less permanently waterlogged.	• Organic matter fixed and starts to degrade in acrotelm, releasing some CO_2 • New peat material enters long-term storage at top of catotelm – little CO_2 released, slow release of CH_4. • Acrotelm may oxidise some CH_4 into CO_2.
Degraded Bog 	• Semi-natural vegetation, but with balance of graminoids/forbs/ericoids and bryophytes changed by adverse/lack of management. • No true acrotelm • Could include forestry if some bog flora remains. • Associated with burning, drainage, afforestation of peatland.	• Water table fluctuates within previously accumulated catotelm peat. • Taller vegetation draws water from peat surface layers.	• Falling litter degrades at peat surface, or in upper peat layers. • Little new organic matter reaches area of permanent waterlogging. • Upper catotelm peat degrades into CO_2 and becomes more decomposed (humified) • More CH_4 is oxidised in upper peat layers • Can be subject to peat shrinkage.
Bare Peat 	• No true acrotelm • No vegetation • Associated with peat cutting, wildfire, pollution, overstocking or cultivation of peatlands. • Some erosion complexes are long-standing and apparently natural.	• Water table fluctuates within previously accumulated catotelm peat. • Upstanding dry haggs alternate with lower wetter but periodically dehydrated peat.	• No new litter entering system • Catotelm peat degrades into CO_2 but extremes of temperature probably retard degradation. • CH_4 emissions may increase – mechanism unknown. • Much peat lost through erosion by wind and water.
Archaic Peat 	• No true acrotelm • Agricultural vegetation (grassland/ cropland) including cultivated land • Forestry where no bog flora remains. • Water table fluctuates within catotelm peat.	• Water table controlled by ditch system • Held typically at ~40-80cm below peat surface • May be brought closer to surface during winter in grasslands.	• Plant litter degrades at peat surface or in upper layers. • Upper catotelm peat degrades into CO_2 and becomes more decomposed (humified). • Cultivation of soil increases oxidation of organic matter releasing more CO_2 • Little CH_4 released – dry surface peat may oxidise atmospheric CH_4 • Peat surface rapidly lowers due to decomposition and erosion of peat.
Wasted or Lost Peat 	• No true acrotelm or catotelm • Most peat has been lost or removed • Agricultural vegetation (grassland/cropland)	• Water table mainly fluctuates within underlying mineral soils	• Peat organic matter increasingly mixed with soil mineral material • Some peat material stabilised • Decomposition of organic matter slows releasing less CO_2 • Little CH_4 released and some atmospheric CH_4 oxidised.

4.3 Describing peatland land use and management

Land management can affect peatlands by modifying their hydrology, changing their geochemical conditions, changing their surface vegetation or disturbing or removing the peat material itself. Some land management types allow the ongoing formation of peat, but many slow or stop it entirely. Different types of peatland are subject to different types of management, each aimed at delivering a specific set of ecosystem services, but which may also adversely affect other peat functions. Many peatland land uses or management types aim to control or influence the vegetation and so these two aspects of peat state are often strongly linked.

As for vegetation and land cover, information on peatland land use and management can be based on mapped areas, or from information relating to a network of points. Data sources available to indicate land management are presented in Appendix I. This section describes a range of common land management practices applied to UK peatlands. The wider implications for peatland ecosystem services are discussed in Section 4.5.

Some key land uses of peatland are described in the forthcoming National Ecosystem Assessment (Van der Wal et al, in review, Maltby et al. in review), and are highlighted in bold. These land uses are briefly described here, along with some additional management practices affecting peatlands specifically.

Some peatlands are **not managed** at all, although it is very rare to find a peatland that is not still influenced by the impacts of past management and land use. Without significant grazing by wild herbivores, many unmanaged peatlands are subject to some level of invasion by scrub and ultimately through natural succession, the development of woodland. Intact bog peatlands are an exception and present a hostile environment to most native woody species, with slow rates of succession. Unmanaged fen peatlands are more likely to support trees, which may then collapse into the peat forming layers of woody debris. However, most unmanaged peatlands are also affected by the impacts of past land management, such as drainage, or are influenced by other environmental factors, such as nutrient pollution, which facilitate succession.

The most common land use for peatland is for **grazing** livestock. Most active peatlands can sustain modest livestock numbers due to the low productivity of the vegetation. Where there are too many grazing livestock, the peat forming vegetation is modified and typically becomes dominated by graminoids – bare peat can also result. Overgrazing became a problem for many upland peatlands during the 20th century because subsidy headage payments encouraged unsustainable stocking rates, although area-based payments have now removed much of the incentive to overgraze. Conversely, in many lowland peatlands historic grazing has ceased, due to changes in the local farming systems, resulting in succession to scrub, and the challenge is to re-establish sustainable grazing. Some upland peatlands are regularly burnt during the late winter to encourage spring growth of grass. This practice encourages the deciduous purple moor-grass (*Molinia caerulea*), because winter burning only removes its dead leaves, but damages winter green plants.

In the late 20th century the drive towards agricultural productivity resulted in government subsidies for **drainage**, the most widespread results of which are the frequent shallow drains (grips) excavated across vast tracts of our upland peatlands. Grips drain the peat surface layers, and deeper peat next to the channel, but also divert water flow away from areas downslope of the grip – they can also initiate/exacerbate peat erosion. Ironically, the benefit of gripping in terms of increased agricultural productivity remains largely unproven. Some areas of upland peatland are affected in a similar way by the legacy of historic peat cutting for fuel, sometimes on an industrial scale, although this practice is now restricted to small scale cutting in Scotland and Northern Ireland.

Many upland peatlands are subject to **grouse moor management**, and support high populations of red grouse (*Lagopus lagopus scoticus*) by regular burning (known as 'muirburn' in Scotland) to provide patches of older and younger common heather for grouse food and nesting cover. This management replaces blanket bog vegetation with that more akin to dry heath.

Upland peatlands, especially those with shallower peaty soils, are used for commercial **forestry**. Soils are deep ploughed or ridges and furrows constructed, to reduce waterlogging, and are normally planted with fast growing, non-native coniferous trees, such as sitka spruce (*Picea sitchensis*). These soils typically produce a commercial crop of timber after about 75 years, but much of the UK's wood products are pulped or chipped.

Large areas of lowland peatland are managed for **agriculture** as improved grassland or cropland. In both cases the land is drained, limed and subject to fertiliser application, and crop plants or forage grasses are sown. Peatlands with arable or root crops are normally subject to deeper drainage than those producing grass. Large areas of shallow peaty soils fringing our uplands have also been converted to improved grassland.

Lowland peatlands have also been **cut for fuel**, or animal bedding in the past, but current mechanised extraction is principally to produce **horticultural growing media**. Lowland peat cuttings were often abandoned to develop into scrub or heath, or to fill with water. Later they may have been used for landfill, or converted to agricultural use, but more recently the emphasis has been more towards the restoration of some form of wetland cover. Peatlands may also be subject to activities to remove or bury the peat to enable infrastructure development or mineral exploitation.

More recently, there has been a growing interest in **restoring peatlands** to encourage more natural peatland functions and characteristics. This can involve re-establishing vegetation on bare peat to slow ongoing erosion, or raising the peatland watertable through dams or sluices to restore peat-forming conditions.

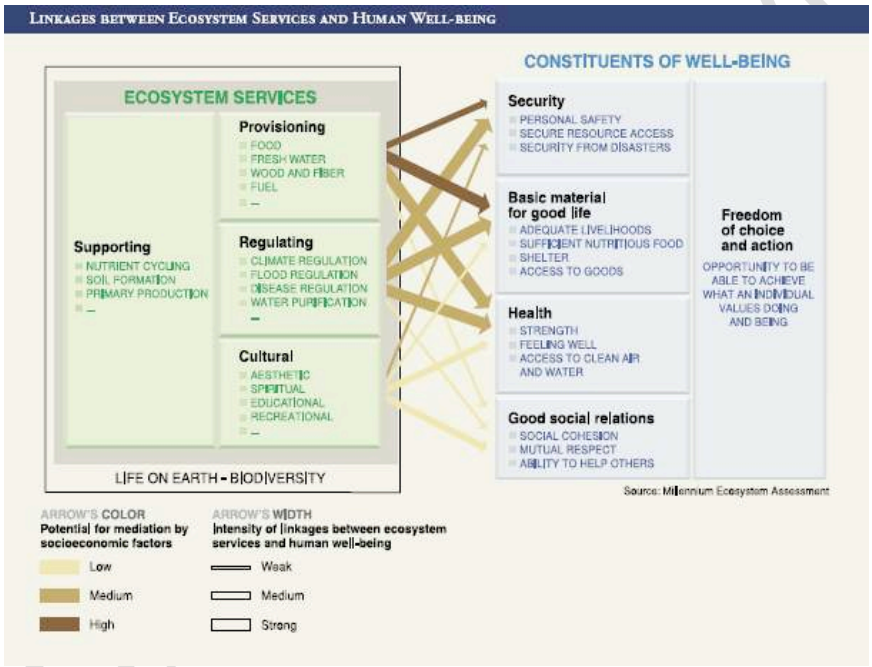
5 Peatland Ecosystem Services

Peatlands deliver a range of goods and services to society; these are often described as ecosystem services, but the concept also recognises costs, or disservices provided by ecosystems. The scale and character of ecosystem services delivered is hugely dependent on the condition of the peatland.

Ecosystem services are defined as services provided by the natural environment that benefit people. The Millennium ecosystem Assessment (MA 2003) is now widely accepted as a framework to identify and categorised range of services (Figure 2). It identifies four broad categories of ecosystem services;

- Provisioning services;
- Regulating services;
- Cultural services; and
- Supporting services.

Figure 2 – Ecosystem services linkages – extract from MA publication, "Living Beyond Our Means: Natural Assets and Human Well-being".



The on-going UK NEA project [(x)] is built upon this approach and will provide a comprehensive assessment of services by 2011 and underline assessment in table 3 and 4.

Table 3 is an attempt to summarise the contributions an active peatland makes to delivery of a wide range of services. The information shown is adapted from the UK NEA projects Freshwater, wetland and floodplains chapter (Maltby, in review), Mountains, Moors and heathlands chapter (van der Wal, in review).

Table 4 indicates how different management practices, when applied to an active peatland, affect delivery of these services. Note that even this qualitative analysis is subject to some uncertainties, not least because the scale and direction of ecosystem service delivery is heavily context dependent.

Table 3. Ecosystem service provided by different types of active peatland - Adapted from UK NEA draft reports (values range from - Negligible to +++ High)

	Bracken	**Dwarf shrub heath**	**Upland fen, marsh, swamp**	**Bogs**	**Montane**	**Fens**	**Grazing marsh**	**Lowland raised bogs**	**Headwater wetlands**	**Wet woodlands**	**Native pine wood**
Likely soil associated	Shallow peat Mineral	Shallow peat Mineral	Deep peat	Deep peat	Shallow peat Mineral	Deep peat	Shallow peat	Deep peat	Mix	Shallow / deep peat	Shallow peat
Provisioning services											
Crops livestock and fisheries	+	+++	+	++	++	+	++	+	+++	+	++
Trees, standing vegetation and peat	-	-	-	+	-	+	+	++	+	+++	+++
Trees for timber, bio/woodfuel	-	-	-	-	-	-	-	-	-	-	-
Wild species diversity	+	+++	+++	+++	+++	+++	++	+++	++	++	++
Water supply	-	-	++	+++	+	+++	++	+++	+++	++	+
Regulating services											
Climate, GHG, carbon	++	++	+++	+++	++	+++	++	+++	+++	+++	++
Hazard	+	+++	+	++	-	+++	+++	++	+++	++	+
Disease and pest	++	++	+	++	+	++	++	+	++	+	+
Pollution control / Detoxification and purification	+	++	++	+++	++	+++	+++	+++	+++	++	+
Pollination	+	+	+	+	+	+	+	+	+	+	+
Cultural services											
Religion and spirituality	+	++	++	++	+++	++	++	++	++	+	+
Cultural heritage / aesthetics	+	++	+++	++	++	++	++	+++	+++	+	+++
Social cohesion	+	++	++	++	+	+	+	+	+	++	++
Tourism and recreation	+	++	+	++	++	++	+	++	+	++	++
Education	+	+	+	+	+++	+	+	++	+	+	+
Supporting services											
Soil formation	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Nutrient / water cycling oxygen production	++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++
Biodiversity	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++

Table 4. Ecosystem services – Comparison of the ecosystem service values of different management practices using active non-impacted peatland systems as a baseline (not considering transitional stages unless otherwise stated) – (based on LCN expert assessment)
▼ show a decrease in ecosystem service function; ▲ show an increase in ecosystem service function; ≈ show no change in ecosystem function ; ≈* (▲) and ≈* (▼) show no change assuming best practices are followed, otherwise change as marked

		Gripping	Burning	Overgrazing	Afforestation	Abandonment	Peat Cutting for Fuel	Peat extraction for horticulture	Agricultural improvement	Cultivation
	Vegetation produced	Wet / Dry Heath	Dry heath, Purple moor-grass	Acid grass	Coniferous forestry	Scrub / Woodland	Wet / Dry Heath	Bare	Improved grassland, Grazing marsh	Cropland
	Peatland type most affected	Blanket bog, Shallow peat	Blanket bog	Blanket bog	Shallow peat, Blanket bog, Raised bog	Raised bog, Fens	Blanket Bog, Raised bog	Raised bog	Shallow peat, Raised bog, Fen	Raised bog, fens
	Peat condition	degraded	degraded	degraded	degraded/archaic	degraded	degraded	bare	archaic	archaic
Provisioning Services	Crops livestock and fisheries	▲	▲	▲	≈	≈	≈	≈	▲	▲
	Fuel or horticultural peat	≈	≈	≈	≈	≈	▲	▲	≈	≈
	Timber or building material	≈	≈	≈	▲	▲	≈	≈	≈	≈
	Genetic resources	▼	▼	▼	▼	▲ / ▼	▼	▼	▼	▼
	Drinking water supply	≈	≈	≈	≈	≈	≈	≈	≈	≈
Regulating services	Carbon storage	▼	≈* *(▼)*	▼	▼/ ≈	▼	▼	▼	▼	▼
	Preventing GHG emissions	▼	▼	▼	▲	▼	▼	▼	▼	▼
	Flood prevention	▼*?*	▼*?*	▼	▼ / ▲	▲	≈	▲	▲	▼
	Disease prevention	≈	≈	▼	≈	≈	≈	▲*?*	▲	▲
	Detoxification and purification	▼	▼	▼	▼	≈	≈	▲	▼	▼
	Pollination	▲	▲	▼	▼	▲	▼	▼	▼	▲*?*
Cultural Services	Religion and spirituality	≈	≈	≈	▲	▲	0	0	▲*?*	▲*?*
	Cultural heritage	▲	▲	▲	▲	▼	▲	▲	▲	▲
	Aesthetics	▲	▲	▲	▼	▼ / ▲	▲	▼	▼ / ▲	▼*?*
	Social Cohesion	≈	▲	≈	≈	▼	▲	▲*?*	≈ / ▲	≈ / ▲
	Tourism and recreation (grouse and game)	≈	▲	≈	▲	▼	▲	▲	≈	≈
	Education	≈	▲	≈	▲	▲	▲	▲	▲	▲
Sup port	Soil formation	▼	▼	▼	▼	▼	▼	▼	▼	▼
	Nutrient cycling	≈	▲	▲	≈	▲	▲	▲	▲	▲
	Biodiversity	▼	▼	▼	▼	▲	▼	▼	▼	▼

Part 2 – The State of the UK peatlands

6 Use of data on the location and extent of peatlands in the UK

In Part 1 of this report we have shown how peatlands are defined, characterised and mapped in the UK. There are fundamental differences between definitions across the UK countries. With the present state of knowledge, it is not possible to develop a system of classification of peatlands that is compatible at UK level.

However, extensive soil and peatland research in each country has provided a body of evidence which can be use to derive country level information on the extent and state of peat soil and peatlands.

For example, in England, the Defra peat project has developed a common system to describe the location of peatlands as Deep Peaty Soils, Shallow Peaty Soils and Soils with Peaty Pockets. This system includes peatlands that have been degraded or lost through agricultural drainage and cultivation as deep peaty soils ('wasted' peat).

In Scotland, the ECOSSE project (Estimating Carbon in Organic Soils – Sequestration and Emissions) (2006) developed a map based on the Soil Map of Scotland, which identified certain Soil Map Units as Peat soils (using the depth and organic matter content specified in Figure 6) and others as Organo-Mineral soils.

The importance of peatlands as a carbon repository is now widely recognised by policy makers in response to the rising awareness of climate change mitigation and adaptation issues. Sustainable management of peatlands for carbon and biodiversity conservation relies on understanding and evaluating the three-dimensional structure of peatlands.

The location of peatlands on a two dimensional map tells us where we are likely to find peat deposits, and can also tell us something about how deep these deposits are likely to be, on the basis of the mapping thresholds used. However, only by understanding the true extent of peat deposits in the third dimension – the peat depth – can we make informed estimates of the importance of peat for carbon storage, understand its hydrological function, and indicate its potential historic environment interest.

Most attempts to map peat depth at the national scale involve using a comprehensive map (such as a soil map) and characterising mapping units based on peat depth measurements from within those units. This approach often applies a relatively small number of peat depth measurements over potentially very large areas (e.g. all peat soils within a country). Peat depth is influenced by the type of peatland (which influences inputs and decomposition of organic matter), topography, drainage, climate, land management and peat condition. Attempts to relate peat depth to the distribution of these factors are likely be more representative than those which only consider the extent of peat deposits.

In Part 2 we review the information that is available first at a UK level and then for each country. The differences in results, from methods used, cannot be compared as like-for-like but must be understood in the context of how the information was derived.

There is little direct information on trends and changes in peatland. The main sources are NSI data on changes in soil properties, the Countryside Survey data and monitoring of UK Priority Habitats.

The UK BAP requires 3-yearly reporting on extent and trends as well as progress on targets. Table 5 provides estimates on the extent and trends on peatland Priority Habitats from the BAP reporting, and data for each country is provided in later sections.

Table 5. Extent and trend of peat forming vegetation Priority Habitats in UK

UK BAP Priority Habitat	**Area (in ha)**	**Summary trend**	**Taken from UKBAP 2008 Reporting** see Biodiversity Action Reporting System (BARS) webpages
Blanket Bog	2,208,533	Declining (slowing)	National action plan - Blanket bog webpage
Lowland Raised Bog	53,347	Fluctuating - probably declining	National action plan - Lowland raised bog webpage
Lowland Fens	25,785	Declining (slowing)	National action plan - Fens webpage
Upland Flushes, Fens and Swamps	-	-	New Priority Habitat so not yet reported on

Vegetation designated within SSSI or ASSI (Northern Ireland) must be assessed at least every six years under UK/country legislation. 'Condition assessment' surveys are undertaken following the JNCC's Common Standards Monitoring guidelines [(X)]. Table 6 provides summary information on the proportion of SSSI/ASSIs or SACs in favourable condition which has been collected by JNCC for the first 6 year report to Government in 2006. More detailed information is being made available at country level [(x)].

The data used in Table 6 represented the most comprehensive available by 2005, but did not represent complete coverage so is only used here as an indication of the condition of peatland vegetation within designated sites across the UK. A number of provisos, such as differences in the methods used by the four countries, are highlighted in the *Common Standards Monitoring for Designated Sites: First Six Year Report* [(x)]. Therefore comparison across the countries is difficult.

Table 6. Condition assessment of peat-forming vegetation features on designated sites in the whole of the UK, showing the proportion of sites in favourable or unfavourable condition. Source: JNCC Common Standards Monitoring for Designated Sites: First Six Year Report

Reporting categories	Favourable	Unfavourable recovering	Unfavourable	Destroyed (whole or part)
Blanket bogs SSSI/ASSIs	58%	15%	27%	0%
Blanket bog SACs	45%	14%	39%	2%
Lowland raised bogs SSSI/ASSIs	22%	35%	41%	2%
Lowland raised bogs SACs	19%	52%	29%	0%
Fens and marshes - upland SSSI/ASSIs	46%	18%	34%	2%
Fens and marshes - upland SACs	45%	19%	36%	0%
Fens and marshes - lowland SSSI/ASSIs	41%	21%	37%	1%
Fens and marshes - lowland SACs	18%	39%	43%	0%

7 The state of peatlands in England

The approach taken by Natural England for assessing in the state of Peatland in England (Natural England, 2010) consider both mapping of peat extent and mapping peat depth. Peat depth information drew on data from the Lowland Peat Survey (Burton and Hodgson 1987), peat depth surveys of Exmoor (Bowes 2006) the Somerset Levels (Cope and Colborne 1981) and Feltwell Fen (Heaven 1997), data from the North Pennines AONB Peatscapes partnership (Leadbitter 2009, pers comm.), and Moor House NNR (Garnett and Ineson 1997), a ground truthing survey for an aerial photo interpretation exercise (Longden 2009) and in-house survey data (Natural England 2009, 2010b). These data were related to units mapping peat origin, cover, management, and condition, extrapolating generalised data for those units lacking representative measurements, to produce a map of peat depth (Natural England 2010b).

7.1 Soil-defined peatland extent

A map showing the extent of England's peatlands was produced by Natural England (2010b) based on the National Soils Map (NSRI 2009), British Geological Survey superficial geology data, and BAP habitat mapping for Blanket Bog. Based on the mapping information presented in Figure 3, the total areas covered by each of the peat types mapped in England are presented in Table 7.

Table 7. Areas of different peatland types in England derived from soils, geological and habitat maps.

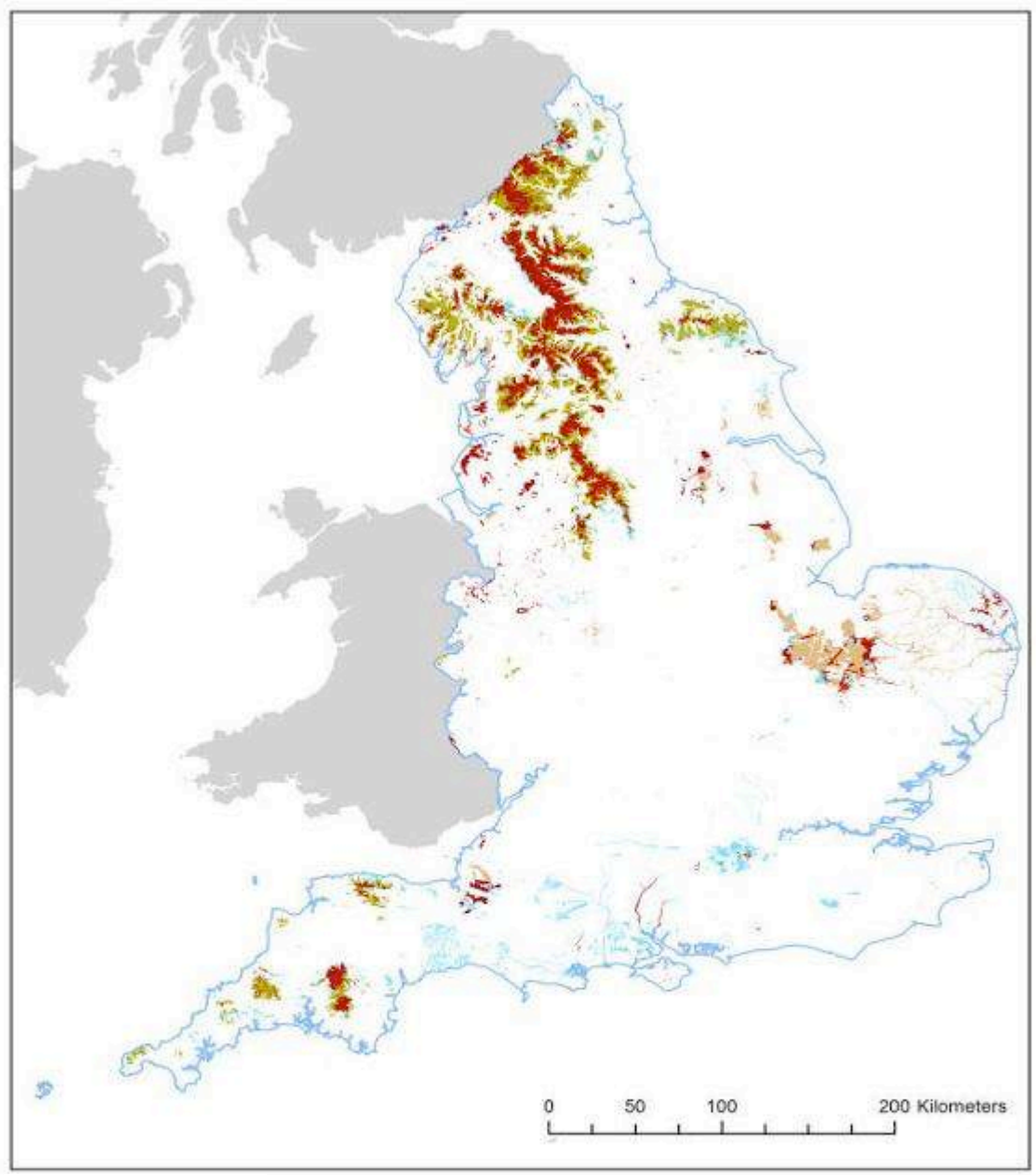
Peat Mapping Class	Area (ha)	% England (%UK)
Deep Peaty Soils*	679,926*	5.2 (2.8)
Shallow Peaty Soils	527,193	4.0 (2.2)
Soils with Peaty Pockets	211,425	1.6 (0.9)
All peaty soil types	1,418,544	10.9 (5.8)

*Includes 192,403 ha of lowland peat wasted through drainage and cultivation

7.2 Extent of different habitat/land cover elements on peat

Natural England has collated all available information to indicate peatland vegetation and land cover, land use and management, and peatland function (hagging and gullying) and ammonia deposition data, and used these data to inform estimates of peatland carbon storage and GHG flux. Figure 4 shows the land cover data collected for this report.

The areas covered by different land cover types, land use types, and areas affected by pollution or peat erosion on deep peat are summarised in Table 8. Table 9 provides similar information for the shallow peatlands and soils with peaty pockets.



Mapping derived from 1:50,000 scale BGS digital data (Licence 2006/072, British Geological Survey © NERC). National Soils map © Cranfield University (NSRI) 2008/09 BAP Habitat mapping (from OS derived data © Crown copyright. All rights reserved 2010. Natural England OS licence no. 100022021

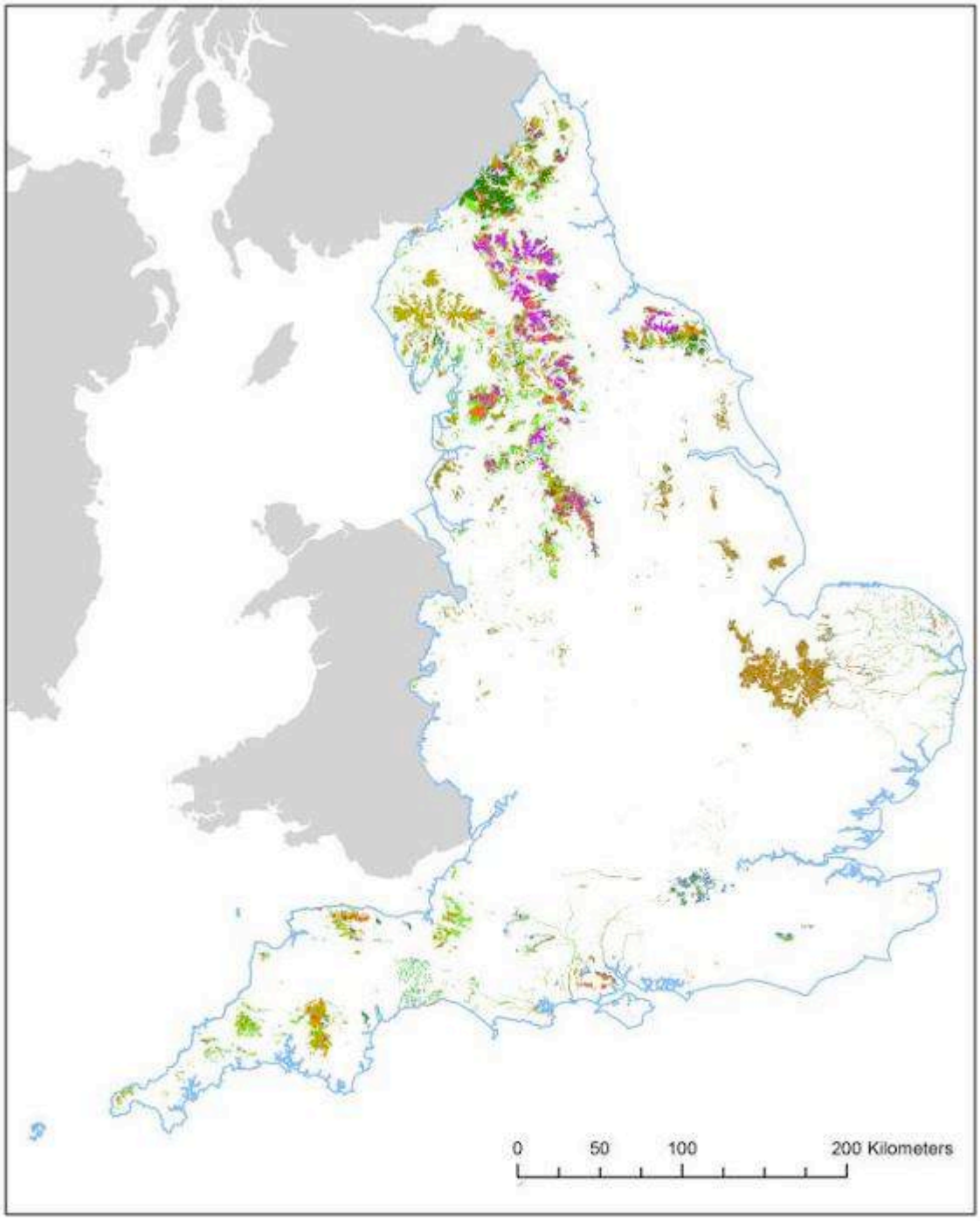
Figure 3 Location of deep peaty soils, wasted fo
soils with pockets of deep peat in England.

Table 8. Areas (in hectares) covered by different peatland land covers and land management practices, and areas affected by ammonia pollution, erosion and wastage in England.

	Blanket bog	Raised bog	Deep fen peatlands	Wasted fen peatlands	no data	All deep peatlands
Undamaged (active peat-forming)	4,468	338	572	341	4	5,803
Purple moor-grass dominated	3,217	21	1	0	0	3,263
Other semi-natural (non peat-forming)	177,942	5,233	11,164	6,599	81	203,048
Scrub	2,900	802	830	140	4	4,818
Wooded	1,652	3,631	6,882	6,959	73	19,748
Bare peat	4,199	19	13	9	0	4,239
Rotationally burnt heathland	105,233	196	1	0	10	105,533
Afforested	23,579	6,159	1,086	2,321	11	33,156
Improved grassland	5,629	5,286	21,208	26,605	48	60,312
Cultivated cropland and temporary grass	440	8,749	37,369	115,033	8	161,732
Gripped	73,604	290	19	0	4	74,107
Old peat cuttings	1,228	4,988	2,763	202	209	9,390
Overgrazed	30,222	14	63	170	1	30,643
Affected by current peat extraction	22	5,550	112	0	1	5,685
Removed or developed	1,024	791	3,105	5,213	10	10,226
Restored	4,590	1,687	3,804	1,379	44	11,587
Hagged or gullied	49,290	11	0	0	10	49,319
Exceeding NH4 deposition for peat forming vegetation	349,716	35,720	6,615	1,045	726	398,798
Wasted	0	198	0	192,205	0	192,403
total area for this peatland type	**355,294**	**35,721**	**95,804**	**192,205**	**902**	**679,925**

Table 9. Areas of shallow peatlands and soils with peaty pockets under different land covers, land managements, and affected by ammonia pollution and erosion.

Peat State	Shallow Peaty Soils	Soils with Peaty Pockets
Undamaged (active peat-forming)	764	338
Purple moor-grass dominated	2,434	38
Other semi-natural (non peat-forming)	239,174	46,005
Scrub	2,252	1,519
Wooded	15,647	30,803
Bare peat	7	3
Rotationally burnt heathland	35,340	3,867
Afforested	65,752	22,135
Improved grassland	112,347	51,108
Cultivated cropland and temporary Grass	6,352	27,851
Gripped	17,025	905
Old peat cuttings	40	24
Overgrazed	13,500	3,192
Affected by current peat extraction	0	31
Removed or developed	6,844	10,943
Restored	1,249	1,667
Hagged or gullied	2,981	24
Exceeding NH4 deposition for peat forming vegetation	209,670	112,559
total areas	**527,192**	**211,424**



Mapping derived from 1:50,000 scale BGS digital data (Licence 2006/072, British Geological Survey © NERC). National Soils map © Cranfield University (NSRI) 2008/09 BAP Habitat mapping (from OS derived data © Crown copyright. All rights reserved 2010. Natural England OS licence no. 100022021

Figure 4. Vegetation and land cover of English peatla

Estimates on the extent and trends of vegetation on peatland Priority Habitats for England from the UK BAP reporting are given in Table 10.

Table 10 Extent and trends of the main peat forming vegetation Priority Habitats in England

UK BAP Priority Habitat	**Area (ha)**	**Summary trend**	**Taken from UKBAP 2008 Reporting** see Biodiversity Action Reporting System (BARS) webpages
Blanket Bog	255,308	Declining (slowing)	National action plan - Blanket bog webpage
Lowland Raised Bog	17,411	Stable	National action plan - Lowland raised bog webpage
Lowland Fens	8,000	Declining (slowing)	National action plan - Fens webpage
Upland Flushes, Fens and Swamps	-	-	New Priority Habitat so not yet reported on

Table 11 presents result from the Countryside Survey data that have been used to infer change in peatlands. There was no detectable change in the estimated area of Broad Habitat Bog in England between 1998 and 2007, following the significant increase between 1990 and 1998. Most of this Broad Habitat occurs in the uplands. There were *no* changes in the mean plant Species Richness Score and vegetation characteristics of Main Plots within the Bog Broad Habitat detected across England as a whole between 1998 and 2007. A significant change in Competitor Score in Bog Broad Habitat was detected only in the Uplands Environmental Zone, where sample sizes are much larger than in other Zones.

For the Broad Habitats Fen, Marsh and Swamp there was no statistically detectable change in area between 1998 and 2007, although there was a significant decrease from 61,000 to 52,000ha in the Westerly Lowlands Environmental Zone. This contrasts with significant increases in area between 1990 and 1998. There was no decrease in the Species Richness Score in Main Plots within Fen, Marsh and Swamp across England between 1998 and 2007.

Table 11 Countryside Survey data for England, showing Broad Habitat extent. (Extract form Countryside Survey – England results from 2007- chapter 7)

	1990 Area ('000s ha)	1998 Area ('000s ha)	2007 Area ('000s ha)	Direction of significant trends 1998-2007
Fens, marsh and swamp				
Total England	78	124	117	
▪ Easterly lowland	9	16	15	
▪ Westerly lowlands	34	61	52	▼
▪ uplands	35	47	50	
Bog				
▪ Total England	98	138	140	
▪ Easterly lowland	10	5	1	
▪ Westerly lowlands	4	7	5	
▪ uplands	84	126	134	

8 The state of peatlands in Northern Ireland

8.1 Soil-defined peatland extent

The extent of peatlands in Northern Ireland was recently reviewed on the basis of the Soils Map of Northern Ireland (Cruickshank 1997), which identified peatlands following the same three tier classification as in England, albeit based on different soil data and definitions of peat. Figure 5 shows the coverage of deep and shallow peaty soils, and soils with peaty pockets in Northern Ireland. Table 12 present the areas covered in Northern Ireland relative to the whole of the UK for deep peaty and peaty soils.

Table 12. Areas of different peatland types in Northern Ireland derived from soils, geological and habitat maps.

Peat Mapping Class	Area (in km^2)	% NI (%UK)
Peat Soils	2,064	14.6 (0.8)
Peaty Soils*	1,417	10 (0.4)
All peaty soil types	3,482	24.6 (1.2)

* defined as humic rankers, peaty podzols, surface water humic gleys, humic gleys and organic alluvial (Cruickshank 1997)

8.2 Extent of different habitat/land cover elements on peat

A range of peatland management issues and uses were captured by the Northern Ireland peatland survey (Cruickshank and Tomlinson 1988), and these have been combined with additional data from the Landcover Map 2000 (CEH 2002) to provide an indicative map of peatland land use and management in Northern Ireland (Figure 6).

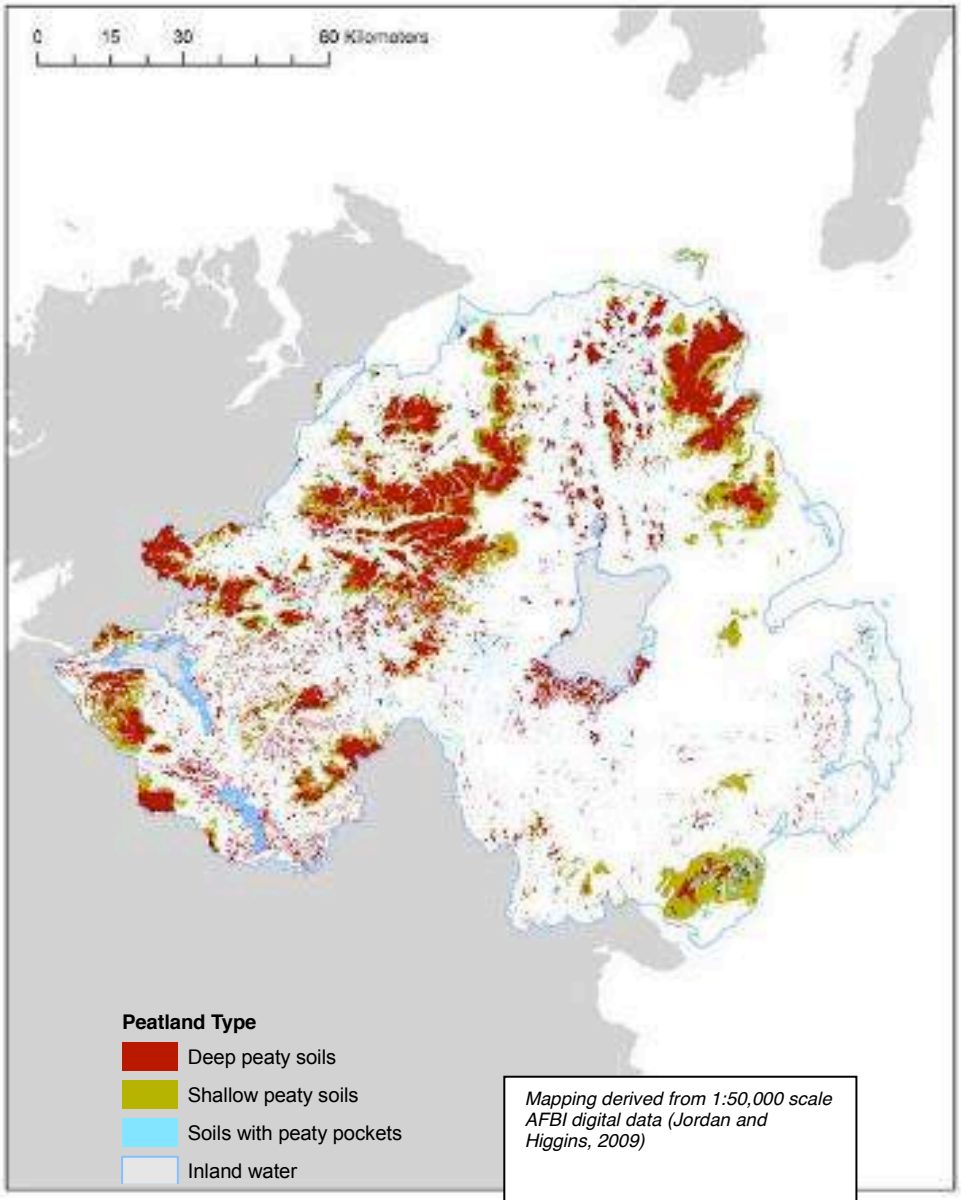


Figure 5. Deep and shallow peaty soils, and soil thern Ireland.

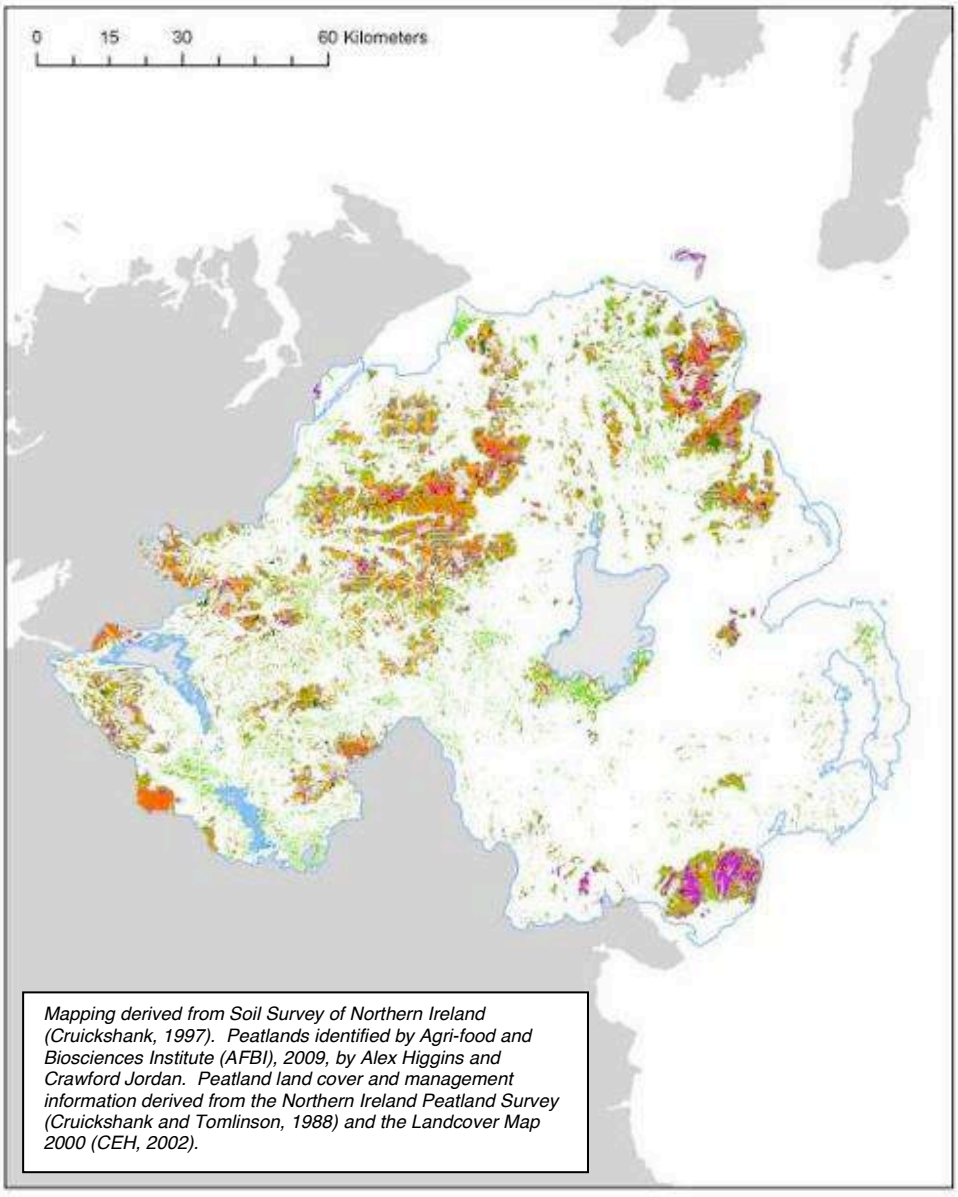


Figure 6. Peatland land use and management in Northern Ireland, based on the Northern Ireland Peatland Survey and Landcover Map 2000 (LCM) classifications.

The state of semi-natural peatlands in Northern Ireland has been reported upon recently under the BARS process (Biodiversity Action Reporting System). Estimates on the extent and trends on peatland Priority Habitats for Northern Ireland from the UK BAP reporting are given in Table 13.

Table 13 Extent and trends of the main peat-forming vegetation Priority Habitats in Northern Ireland

UK BAP Priority Habitat	**Area (in ha)**	**Summary trend**	**Taken from UKBAP 2008 Reporting** see Biodiversity Action Reporting System (BARS) webpages
Blanket Bog	139,796	No clear trend	National action plan - Blanket bog webpage
Lowland Raised Bog	21,106	Declining (slowing)	National action plan - Lowland raised bog webpage
Lowland Fens	3,000	Declining (slowing)	National action plan - Fens webpage
Upland Flushes, Fens and Swamps	-	-	New Priority Habitat so not yet reported on

Table 14 presents result from the Countryside Survey data that have been used to infer change in peatlands.

The Broad Habitat (Fen, Marsh and Swamp) in Northern Ireland consists of rush-dominated vegetation on peaty soils, marshy grassland and water-inundated vegetation. Although there is no statistically significant changes in any of Primary Habitats, the main changes were losses to tree planting and to bog primarily in the marginal upland.

The Broad Habitat (Bog) consists of a wide range of peatland types. There was a significant reduction in extent of the primary habitat 'wet heath' to dry bog, wet mixed heath and transitional semi-natural woodlands/scrub. Others changes are loss to scrub succession at the edge of bog complexes, changes to neutral grassland and fens, and changes to marsh and swamp broad habitats.

Table 14 Countryside Survey data for Ireland, showing Broad Habitat extent. (Extract from Northern Ireland Countryside Survey 2007 (Cooper et al 2009))

	1998 Area ('000s ha)	2007 Area ('000s ha)	Direction of significant trends 1998-2007
Fens, marsh and swamp			
Total	50,211	47,067	
▪ Species-rich wet grassland	13,396	13,186	
▪ Fen meadow	6,533	5,290	NO SIGNIFICANT CHANGE
▪ Poor fen	24,784	21,005	
▪ swamp	2,280	2,499	
▪ reedbeds	2,958	2,524	
▪ water inundation vegetation	260	2,563	
Bog			
Total	164216	160,902	
▪ wet bog	50,696	46,905	
▪ dry bog	43,262	49,453	
▪ Molinia grassland	6,276	6,238	
▪ Wet heath	61,719	48,559	▼
▪ Wet mixed heath	2,263	9,747	

9 The state of peatlands in Scotland

Recent studies funded by Scottish Government (ECOSSE project, the RERAD "Protecting the nation's soil " programme 2006-11) have provided new information on the extent and structure of organic-rich soils in Scotland. A summary of the results appears in the web publication of the findings of an Expert Workshop to establish the current state of knowledge of and future evidence needs for the extent and condition of carbon stocks in Scottish peatlands (Chapman et al 2009).

Recent research has re-examined peat polygons from the digitised soil map of Scotland, and related these to measurements from peat survey transects in the early 1990s, state surveys of peatlands in the 1960s, data on bogs held by MLURI from the Soil Survey memoirs, maps and other sources, commercial peat extraction data and Forestry Commission survey reports. These were used where possible to characterise soil map units in terms of peat depth, and generalised results for peat depth were applied to those where peat depth data were absent. The resulting peat depth map was combined with figures for peat bulk density and carbon content to estimate the carbon stored in peat soils.

9.1 Soil-defined peatland extent

The location and extent of Scottish peatlands is shown in Figure 7, while Table15 details the coverage of different types of peatland soils in Scotland.

Table 15. Extent of peat map units in Scotland based on the Soils Map of Scotland (MLURI).

Peat Map Units	Area (km2)	% Scotland (% UK)
Basin Peat	673	0.9 (0.3)
Eroded Basin Peat	8	0.0 (0.0)
Blanket Peat	3,711	4.7 (1.5)
Deep Blanket Peat	1,679	2.1 (0.7)
Eroded Deep Blanket Peat	309	0.4 (0.1)
Eroded Blanket Peat	1,259	1.6 (0.5)
PEAT WITHIN OTHER MAP UNITS		0.0 (0.)
▪ Basin Peat	54	0.1(0.0)
▪ Semi-confined Peat	5,423	6.9 (2.2)
▪ Blanket Peat	4,155	5.3 (1.7)
TOTAL	17,269	21.9 (7.1)

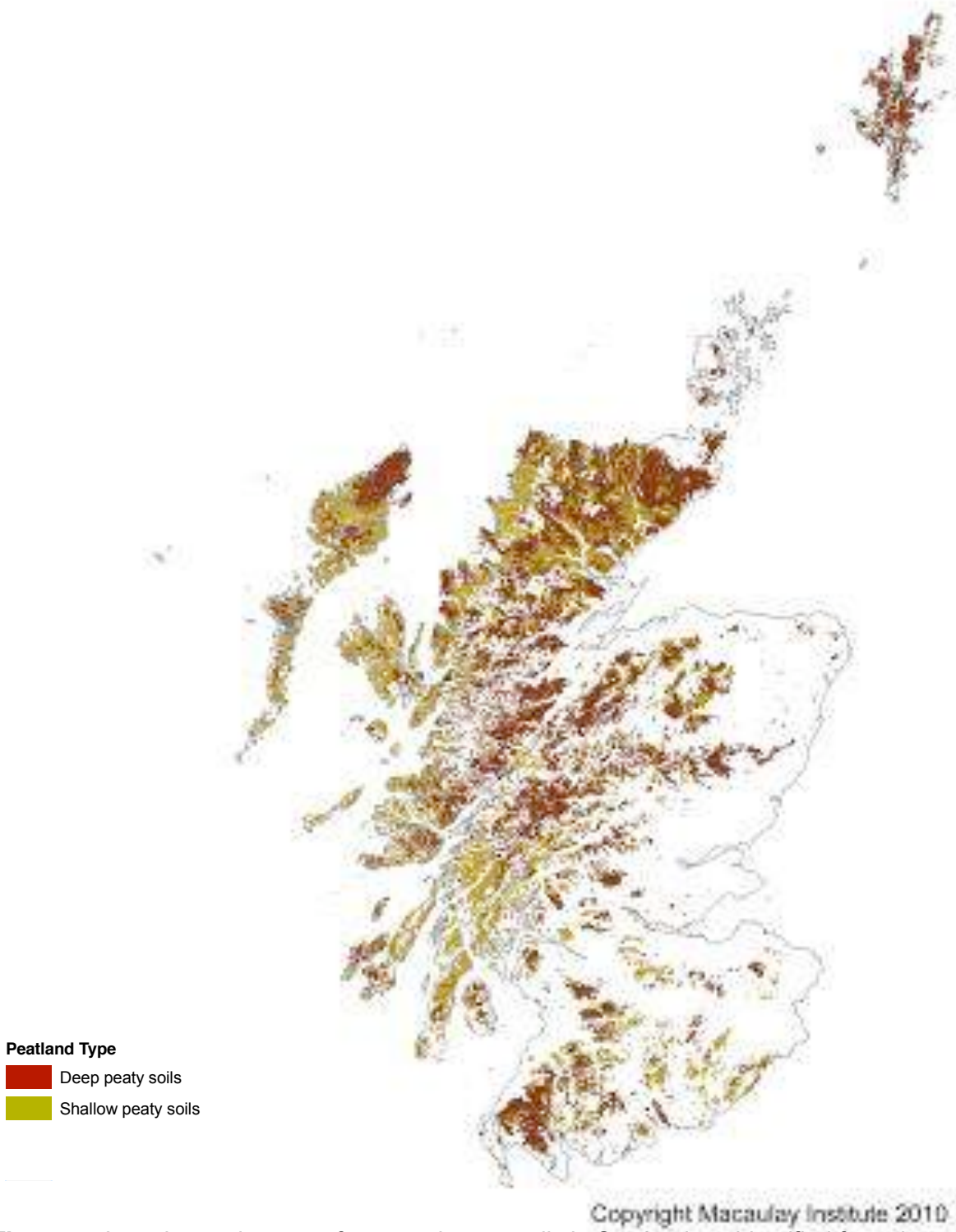


Figure 7. Location and extent of peat and peaty soils in Scotland, as identified from the Scottish Soils Map,

9.2 Extent of different habitat/land cover elements on peat

The LCS88 vegetation maps available for Scotland have been used in place of LCM for BAP reporting in Scotland. The LCS88 map shows peatland habitats as a single feature covering over 8.4 % of Scotland's land area, and together with heather moorland as feature mosaics representing a further 22.3% (Figure 8).

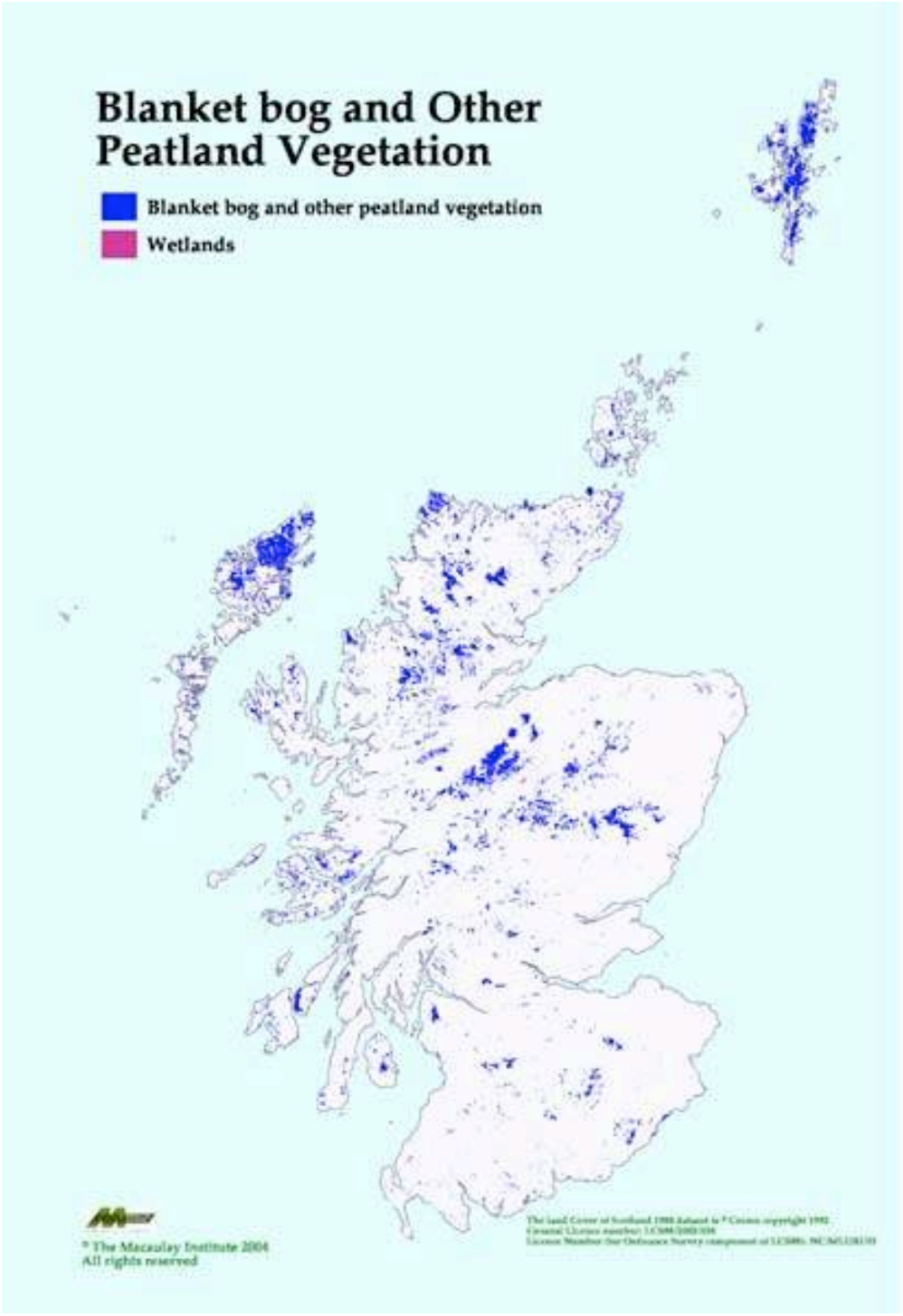


Figure 8 Land cover Scotland 1988 (LCS88) – *map to be redrawn to include all peatland vegetation types.*

Estimates on the extent and trends of peatland Priority Habitats for Scotland from the UK BAP reporting are given in Table 16.

Table 16 Extent and trends of the main peat forming vegetation Priority Habitats in Scotland

UK BAP Priority Habitat	**Area (in ha)**	**Summary trend**	**Taken from UKBAP 2008 Reporting** see Biodiversity Action Reporting System (BARS) webpages
Blanket Bog	1,759,000	Declining (slowing)	National action plan - Blanket bog webpage
Lowland Raised Bog	13,000	Declining (slowing)	National action plan - Lowland raised bog webpage
Lowland fens	8,585	Declining (slowing)	National action plan - Fens webpage
Upland Flushes, Fens and Swamps	-	-	New Priority Habitat so not yet reported on

Table 17 presents results from the Countryside Survey data that has been used to infer change in peatlands. The Broad Habitat 'Bog' in Scotland represents over 85% of known habitats in the UK. No significant change was detected in Scotland between 1998 and 2007, but a significant decrease of 2.5% was observed for EZ4 (Lowlands). The mean plant Species Richness Score of Main Plots within the Bog Broad Habitat in Scotland decreased by 6% between 1998 and 2007.

The Broad Habitat 'Fens, marsh and swamp' in Scotland represents around 54% of the UK stock. No significant change was detected between 1998 and 2007. There was a significant change (23% decrease) in Species Richness Score between 1998 and 2007, and an 18% decrease between 1990 and 2007. Decreases between 1998 and 2007 appear to be particularly concentrated in the Lowlands (EZ4).

Table 17 Countryside Survey data for Scotland, showing Broad Habitat extent. (Extract form Countryside Survey – Scotland results from 2007- chapter 7)

	1990 Area ('000s ha)	1998 Area ('000s ha)	2007 Area ('000s ha)	Direction of significant trends 1998-2007
BH - Fens, marsh and swamp				
Total Scotland	289	261	238	
▪ EZ4 (Lowlands)	58	72	71	NO
▪ EZ5(Intermediate Uplands and Islands)	151	109	95	SIGNIFICANT CHANGE
▪ EZ6 (true Upland)	80	80	72	
BH - Bog				
Total Scotland	1,922	2,039	2,044	
▪ EZ4 (Lowlands)	158	160	156	▼
▪ EZ5(Intermediate Uplands and Islands)	832	872	890	
▪ EZ6 (true Upland)	932	1,006	998	

10 The state of peatlands in Wales

In Wales, estimates provided by Taylor (1974), were combined with information from the lowland peat survey (Burton and Hodgson 1987), peat depth from the Dee catchment and National Soil Inventory sites (up to 1m of peat depth), Forestry Commission sites, and more recent surveys of upland areas presented in the ECOSSE report. These were combined with data from the Welsh soils map and land use data to generate a map of peat depth for Wales. Data were also used to input into a model to predict peat depth and carbon storage based on topography and climate.

10.1 Soil-defined peatland extent

Soil mapping data (based on the Soil Map of England and Wales) indicates a total extent of peat in Wales of 70,600 ha. However, because this estimate is based on soil association level data, it is likely to both over-estimate the extent of peat where peat associations include organo-mineral or even mineral soil series, and under-estimate the extent of peat where mapped 'non-peat' associations include peaty series. This latter issue is likely to apply mostly to the lowlands and upland fringes where peat is very widespread in topogenous hollows but only rarely extensive (i.e. >50 ha). Complete loss of peat has been documented at a few sites, primarily due to peat cutting.

The Habitat Survey of Wales (Blackstock et al 2010) provides reliable information on peatland extent for the bog and topogenous fen categories because mapping as these categories was conditional on the presence of at least 0.5 m of peat (Blackstock et al 2010). The addition of these data to the soil survey results as interpreted by the ECOSSE project is shown as Figure 9 and Table 18. This provides the most up-to-date assessment of the Welsh peatland resource.

Table 18. Areas of different peatland types in Wales derived from soils, geological and habitat maps. Data derived from ECOSSE study.

Peat Mapping Class	Area (in km^2)	% Wales (%UK)
Peat Soils	706	3.0 (0.3)
Peaty Soils	3,592	17.3 (1.5)
All peaty soil types	4,298	20.3 (1.8)

* defined as humic gleys, humic rankers, stagnohumic gleys and stagnopodzols

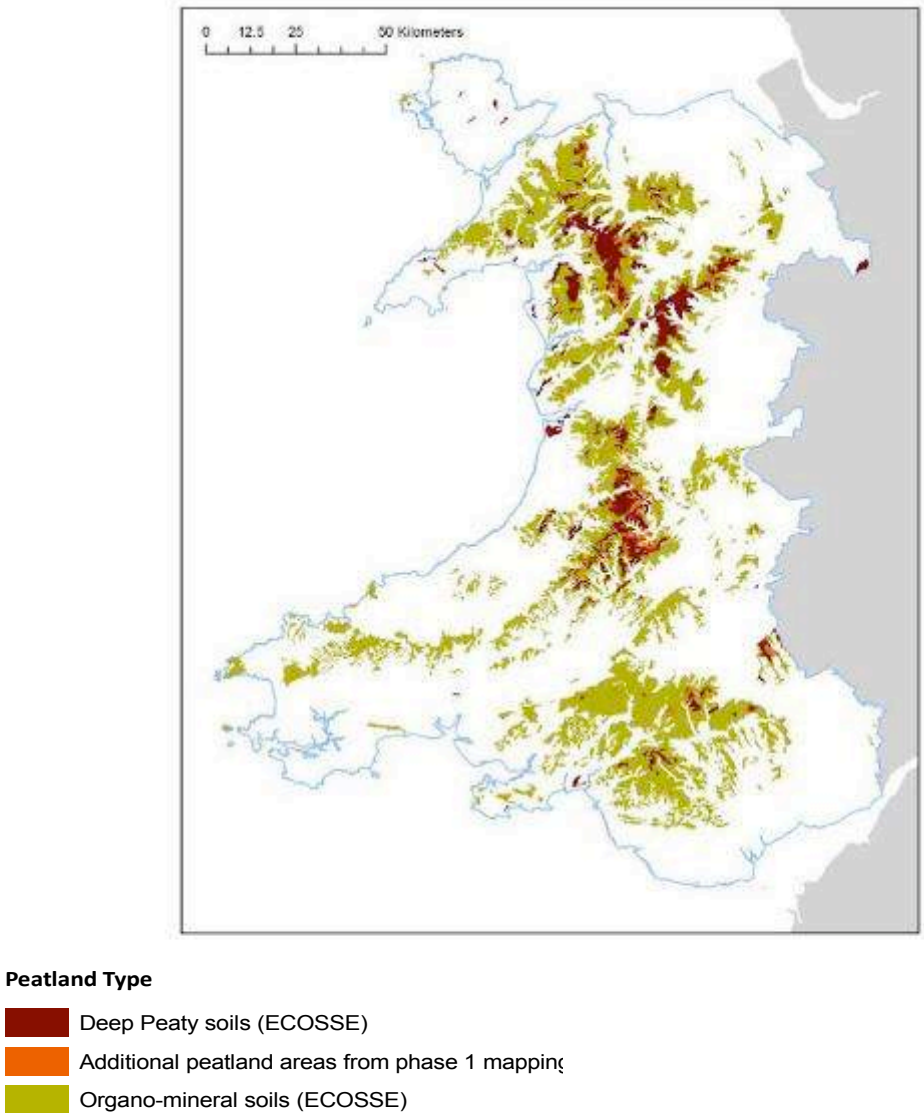


Figure 9. Location and extent of peatlands in Wales. Mapping of deep peat and organo-mineral soils from the ECOSSE project has been augmented by data on bogs and topogenous fens from the phase 1 map of Wales.

10.2 Extent of different habitat/land cover elements on peat

The total extent of mire habitats recorded from the Welsh Phase I survey is shown below in Figure 10 and Table 19. The sum total figure of 79,000 ha is close to the 70,600 ha figure for mapped peat, but some of the topogenous fen and swamp and soligenous fen (flush and spring) categories will include mire vegetation on shallow peat. Furthermore, approximately 9,000 ha of conifer plantation occurs on peat, together with significant areas of heath and acid grassland, especially in the uplands. Archaic peat, typically under improved grassland, is principally associated with the major estuaries of the west coast.

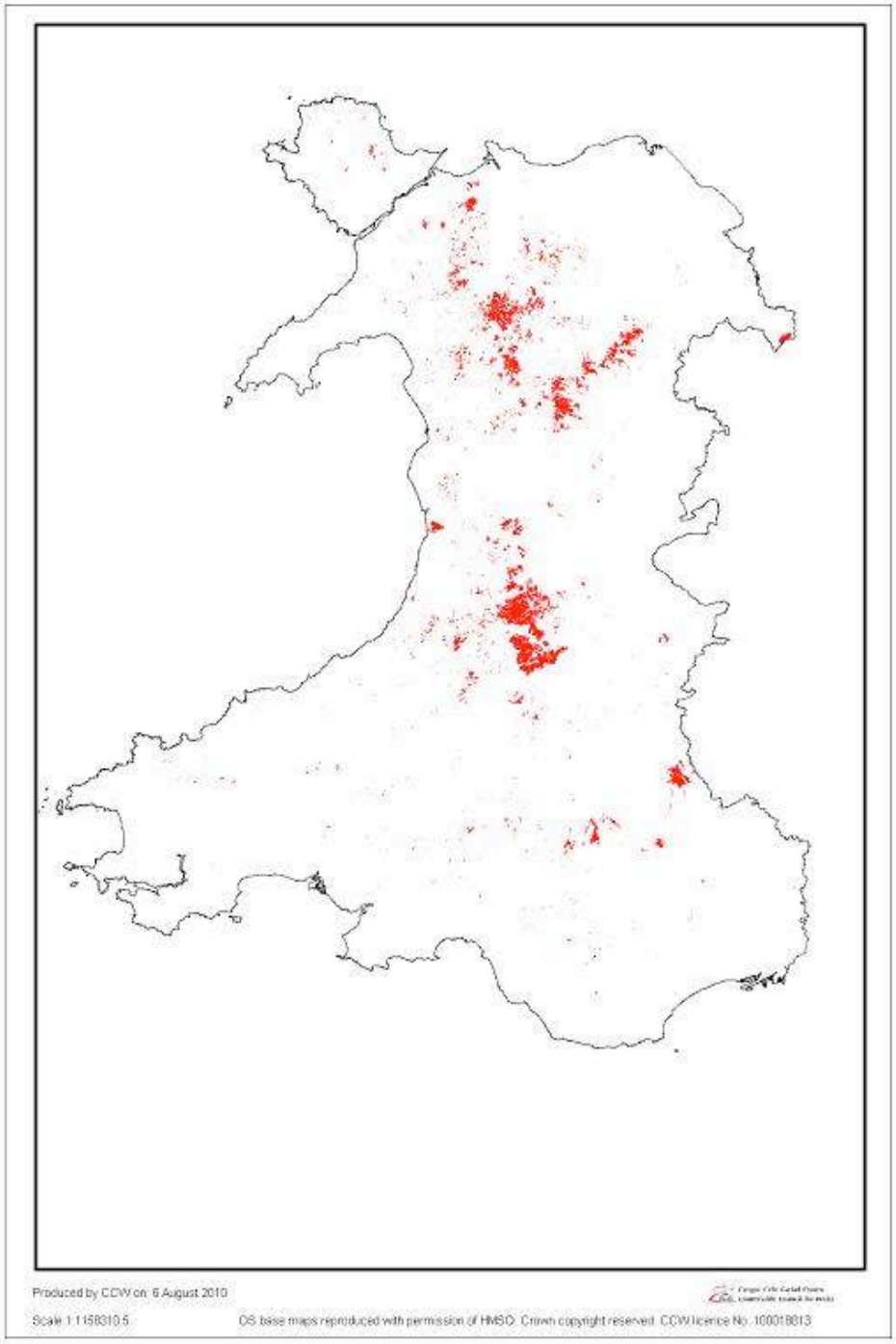


Figure 10. Map of phase 1 Peatland habitats. To be redrawn with different colour for different habitats (does not include improve grassland and scrub class**)**

Table 19 - Extent of priority habitats – phase I Habitat survey in Wales

Habitat	**Lowland** Area ('000s ha)	**Upland** Area ('000s ha)	**Wales total** Area ('000s ha)
Blanket bog – un-modified	500	22,600	23,000
Blanket bog - modified	1,200	32,000	33,200
Raised bog - unmodified	990	40	1,000
Raised bog - modified	820	0	820
Topogenous fen and swamp - unmodified	3,800	1,300	5,100
Topogenous fen and swamp - modified	770	300	1,100
Soligenous fen	2,100	12,700	14,800
Totals	10,100	68,800	79,000

A significant proportion of the habitat cover of Welsh peatlands is regarded as modified – this is the predominant cover type for blanket bog, the most abundant peatland type in Wales. Modification reflects the current and recent pressures of over- (and sometimes under-grazing), peat cutting, past burning and atmospheric deposition.

Estimates on the extent and trends of peatland Priority Habitats for Wales from the UK BAP reporting are given in Table 20.

Table 20 Extent and trends of peat forming vegetation Priority Habitats in Wales

UK BAP Priority Habitat	**Area (in ha)**	**Summary trend**	**Taken from UKBAP 2008 Reporting** see Biodiversity Action Reporting System (BARS) webpages
Blanket Bog	70,000	Declining (slowing)	National action plan - Blanket bog webpage
Lowland Raised Bog	1,830	Declining (slowing)	National action plan - Lowland raised bog webpage
Lowland Fens	6,200	Declining (continuing / accelerating)	National action plan - Fens webpage
Upland Flushes, Fens and Swamps	-	-	New Priority Habitat so not yet reported on

Table 21 presents results from the Countryside Survey data that have been used to infer change in peatlands. The Broad Habitats 'Bog' in Wales is mainly located it the Uplands and shows no significant change between 1998 and 2007 and no significant change in mean plant Species Richness Score of Main Plots.

The Broad Habitat 'Fens, marsh and swamp' type is found in lowland (1.3% of the zone) as well as upland (2.1% of the zone) areas favoured by the wet oceanic climate and the presence of poorly drained soils that are found throughout the country. The area of this habitat did not change significantly between 1998 and 2007.

Table 21 Countryside survey data for Scotland, showing Broad Habitat extent. (Extract form Countryside Survey – Wales results from 2007- chapter 6).

	1998 Area ('000s ha)	2007 Area ('000s ha)	Direction of significant trends 1998-2007
Fens, marsh and swamp			
Total Wales	40	36	NO
▪ Upland	15	14	SIGNIFICANT
▪ lowlands	24	22	CHANGE
Bog			
Total Wales	45	48	NO
▪ upland	8	40	SIGNIFICANT
▪ lowlands	36	8	CHANGE

11 Discussion and conclusions

This report reviews our current understanding of the nature of UK peatlands and provides the basis for presenting a comprehensive picture of the extent and state of peatlands across the UK. This is the first time that such peatland information has been brought together and it is hoped that understanding the differences in the data available will help address how the information is used.

It is clear that despite broad agreement on what constitutes a peatland, there is little convergence on methods used to describe and quantify peatlands across national boundaries and specialist topics.

Peatlands are **defined** as "*ecosystems with a peat deposit that may currently support a vegetation that is peat-forming, may not, or may lack vegetation entirely".* Because of this dual vegetation / soil perspective, the **description / characterisation** of peatlands results from the re-interpretation of a range of information on soil type, vegetation cover, land use, land management, hydro-morphology, geology, topography and environmental pressures.

Most of the information available has been collected over many decades to inform specific operational and policy requirements following historically-based methodological frameworks. As a result a variety of typologies, classifications and mapping systems have been used to describe, measure and report on the soil and vegetation used to define peatland. This creates difficulties in having a common understanding and language on information about the state of peatlands. For example, the shallow peat construct is applied differently between England & Wales and Northern Ireland, and is not formally recognised in the soil classification for Scotland (see Figure 1).

In part driven by the Climate Change mitigation agenda, extensive work is being undertaken at the UK level to overcome those classification differences and monitor soils to improve our estimate of the soil carbon stock. Revision of the depth and location of peat soil is a valuable contribution to any review of the extent of peatlands.

Differences in vegetation descriptions also complicate assessment of UK peatland. Values reported for the extent of Broad and Priority Habitats are highly dependent on methodology. Vegetation definition, methodology, and scale of reporting can also contribute to the differences observed in Part 2 of the report for each country. For example, the reported extent of the UK BAP Priority Habitat blanket bog in England is over 2500 km^2, but CS2007 only reported 1400 km^2 in the bog Broad Habitat category and the Natural England estimate extent of Bog Priority Habitats is 3500 km^2.

There is limited information on state and trends as surveillance programme and monitoring scheme are sparse at the UK level. It often only considers limited aspects of peatland ecosystems in isolation (e.g. national soil inventory, broad habitats survey) or focuses on specific locations (eg international reporting obligation on protected sites). Such information is very useful within its context but can not always be used to provide a national assessment of peatland state and changes.

The report clearly shows that valuable evidence on the extent and the state of peatland can be inferred for each country. However, there are limitations and barriers to combining the information across countries.

There is even more limited information available to enable interpretation of how peatlands respond to change.

We need now to understand how we can take forward this old paradigm into a 'fit for purpose' assessment of peatlands in the UK which will contribute to their sustainable management.

Within the limits of the information that we have available how can we address future information needs? To answer this we need to address a range of other questions:

- What is the information to be used for? – Currently this is primarily to fulfil international (e.g. Kyoto, Convention on Biological diversity), EU, UK and country obligations, legislation and policy (climate change, renewables, biodiversity, land-use). A clear understanding of what the information is needed for helps determine what information is needed, which in turn provides a focus for the development of appropriate data-gathering methods.

- Can we make better use of existing peatland information and if so, how?

- Can new technology, particularly in the field of remote sensing improve our understanding of peatland extent, condition and trends at an acceptable cost.

- Where current information needs are not, and cannot readily be, met what are the research requirements to address data and methodological gaps?

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Appendix I: Data sources indicating peatlands vegetation and land cover

Area-based information – database and maps in the public domain or available under licensing agreements (all web-links accessed 3 August 2010)

Data source	Description	Comments
UK Landcover Map 2000 (2007 imminent) Available from: http://www.countrysidesurvey.org.uk/land_cover_map.html	• Covers all UK • Based on remote sensing data, with ground truth survey calibration • Reports on 26 different land covers based on UK BAP Broad Habitats • Available under licence from CEH	• Good accuracy for enclosed land, less accurate in upland and unenclosed areas • An update based on 2007 data planned for release autumn 2010 • LCM 2000 has been used as basis for developing map English Priority Habitats, but not elsewhere in UK
Land Cover Scotland (LCS, MLURI, 1988) Available from: http://www.macaulay.ac.uk/explorescotland/lcs_mapformat.html	• Covers Scotland • Based on aerial photo interpretation • Reports 127 different land covers • Available under licence from MLURI	• Comprehensive coverage but information now dated
Phase 1 Habitat Map of Wales (Howe et al, 2004; Blackstock, 2010)	• Covers Wales • Based on ground survey from 1979 to 1997. • Uses JNCC phase 1 survey method (JNCC, ref!) • Maps to a hierarchical system of habitats and subtypes • Available under licence from CCW	• Ground survey technique for bogs requires peat depth testing, so can be used to inform peat extent mapping • Can be used to distinguish finer scale habitat differences relating to management • Used in Wales to report on UK BAP habitats
Biodiversity Action Reporting System (BARS, 2010) Available from: http://www.ukbap-reporting.org.uk/plans/national.asp	• Estimate of area extend and trend of UK BAP Priority habitats in UK	• Data collated from various sources at different scales using different approaches • Often difficult to interpret • Upland flushes, fens and swamps recently recognised as a Priority Habitat and not yet been mapped/reported
Northern Ireland Peatland Survey (Cruickshank, 1988)	• Covers Northern Ireland's semi-natural peatlands	• Does not cover peatlands under forestry or agriculture

Data source	Description	Comments
	• Mapped from management recorded • Identifies bare peat, heathland	
Countryside Survey 2000 and 2007 For reports see http://www.countrysidesurvey.org.uk/reports2007.html	• Covers all GB and along with The Northern Ireland Countryside survey provides a UK report on Broad Habitats • Repeated survey, conducted every 6-8 years since 1978 • Characterises, or samples within a network of ~900 1km squares representing the range of broad UK rural land covers	• Scotland and Northern Ireland have used Countryside Survey 2000 (point based) for UK BAP reporting • Used to inform reporting on Favourable Condition Status of EU Habitats Directive Annex I Habitats, including undesignated areas (JNCC, 2007)
Northern Ireland Countryside Survey http://www.ni-environment.gov.uk/biodiversity/nh-research/nicountrysidesurvey-2.htm	• Covers Northern Ireland • Previous surveys reported in 1992 and 2000 • Uses a sample set of quarter kilometre grid squares throughout NI • Changes are presented at the Primary Habitat level as well as Broad Habitat • Results integrate with Countryside Survey GB	• Used in Northern Ireland for UKBAP Reporting

A/SSSI and SAC survey, monitoring and inventories	• Vegetation mapping using NVC within some A/SSSI and SAC sites (esp Scotland)
	• All A/SSSI assessment units are mapped and have specified habitat feature interests
	• Some more detailed information is digitised and available from the country conservation agencies
		• Limited to peatlands within designated sites.
		• Mapping of habitat feature interests is indicative but not accurate
		• Incomplete detailed mapping within designated sites
		• Some detailed surveys now quite dated.
		• On line information available for each country
		  ○ Scotland http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/site-condition-monitoring/
		  ○ England http://www.sssi.naturalengland.org.uk/Special/sssi/search.cfm
		  ○ Wales http://www.ccw.gov.uk/landscape--wildlife/protecting-our-landscape/special-landscapes--sites/protected-landscapes/sssis/sssi--report.aspx

Data source	Description	Comments
		○ Northern Ireland http://www.ni-environment.gov.uk/protected_areas_home/area_interest.htm
National Peat Resources Inventory (Lindsay & Immirzi,1996)	• Covers all UK raised bogs and fens • Reports active, secondary, scrub, agricultural peatlands	
Integrated Agricultural Control System	• Collects information to support payment of SPS and former agricultural subsidies • Records detailed agricultural land use information relating to points in the centre of fields	• Point information is prone to plotting errors • Very large range of managements indicated • Currently being examined for utility in GHG inventory reporting in Scotland
English Upland photo interpretation	• Source - Assessing the state of upland peatlands by Aerial Photo Interpretation (Longden, 2009) • AP assessment at 1:5000 scale with limited ground truthing survey • Covers all English moorland deep peat	• Focus is on management, but also includes bare peat and some non-moorland vegetation types
Local Environment Record Centre Vegetation surveys	• Uses Phase 1 methodology (see Wales above), NVC (Rodwell, 1992, 1998 etc., and other survey methods • Patchy coverage of surveys • Only some areas digitised • Conducted over a range of dates • Available under agreement with LERC	• Point information is prone to plotting errors • Very large range of managements indicated • Currently being examined for utility in GHG inventory reporting in Scotland
Restoration projects	• Collects information to support payment of SPS and former agricultural subsidies. • Records detailed agricultural land use information relating to points in the centre of fields	• Point information is prone to plotting errors • Very large range of managements indicated. • Currently being examined for utility in GHG inventory reporting in Scotland
Agri-environment schemes	• Mapped areas of land managed under agri-environment agreements • Data collected since early 1990s.	• Can identify active bogs, fens, scrub, woodland, cropland, improved grassland and a range of semi-natural non-peat forming habitats

Data source	Description	Comments
	• Management options often apply to certain vegetation or land cover types • Scattered coverage • Data availability is restricted	