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Towards an assessment of the state of UK Peatlands

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In Memoriam

For Mark Crick, our colleague from JNCC, in recognition for all his valuable work in taking forward this publication to completion.

Summary

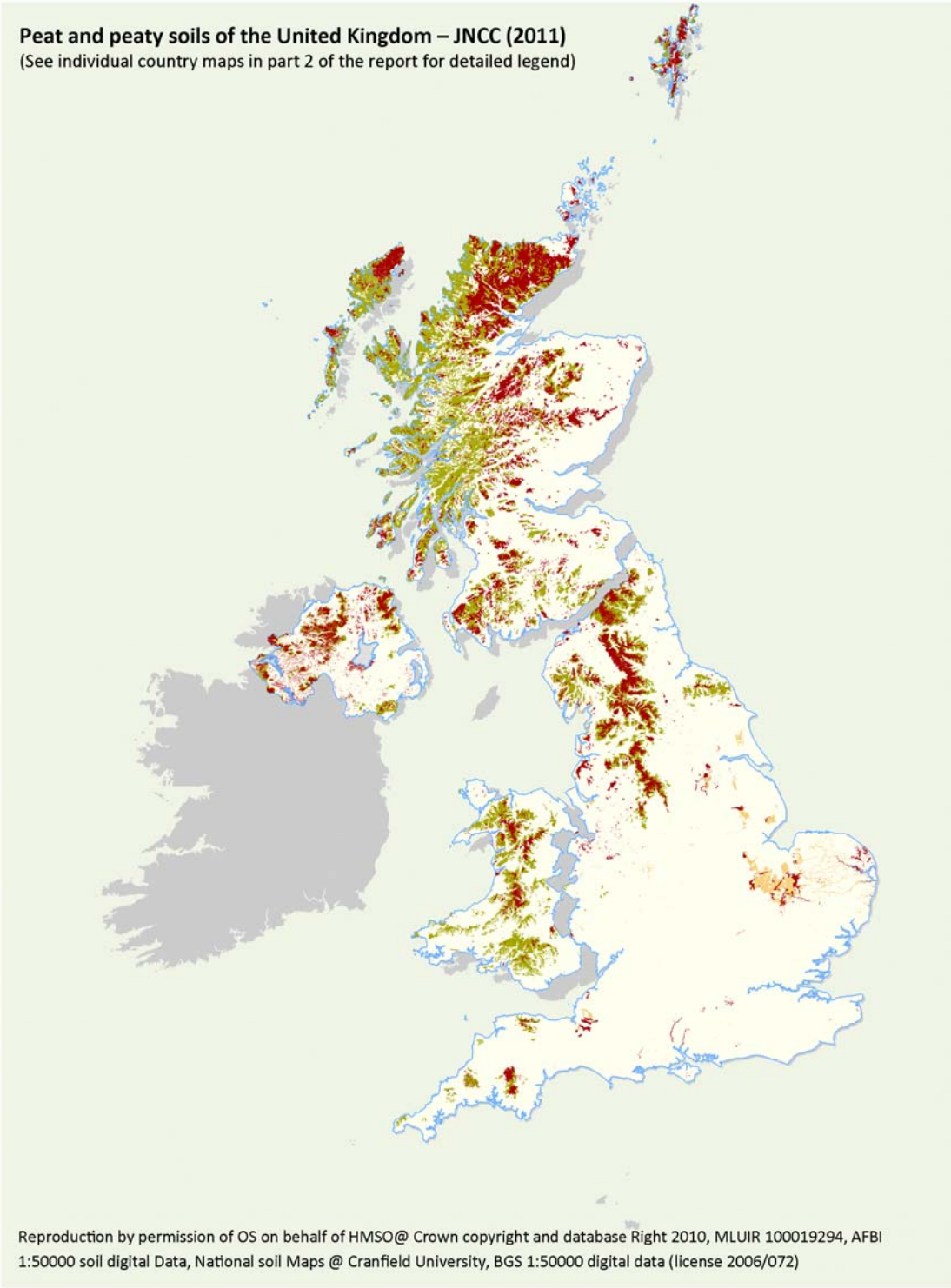
This report assesses the state of the UK peatlands, based on available information on the extent, location and condition of peat soil and peatlands, vegetation, land cover, land use, management and a range of environmental influences. The report also provides estimates of extent and condition of peatlands in each of the four UK 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 or 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 broadly into two parts. The first part (section 2-5) addresses how we define, delineate and describe peatlands, and considers critically the sources of available information. This part also touches briefly on the likely impact of peatland management on the ecosystem services delivered by peatlands. The second part (section 6-10) provides a synopsis of the state of peatlands in the four countries.

The review also includes a glossary of terms and definition used in the UK to describe peatland soils and habitats types and conditions.

There are still insufficient data and information to provide a definitive overview of the state of the UK's peatland resource as a whole. This report identifies key gaps in current knowledge necessary to provide a fit-for-purpose assessment of peatlands across the UK.

Contents


Peat and peaty soils of the United Kingdom – JNCC (2011)
(See individual country maps in part 2 of the report for detailed legend)
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1 Introduction

The term 'peatland' conjures immediately recognisable images in the UK. These are often characterised by vegetation, or by the visual presence of peat itself, and can include wild upland moors, bogs, fens 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, and recognising where some definitions may be unhelpful, before going on to address the current state of peatland soils and habitats in the UK.

Peatlands are unique ecosystems which preserve a detailed record of their development in the form of partially decomposed plant and animal remains. Over centuries and millennia, the slow accumulation of soil organic matter has created deep peat deposits which hold a key role in storing terrestrial carbon. Peatlands also provide unique habitats and biodiversity which are recognised under international and national legislation.

Peatlands covers around 4 million km^2 or 3% of the world land area, and are found from the tropics to circumpolar regions (see the IMCG Global Peatland database: www.imcg.net/gpd/gpd.htm). In Europe, recent estimates of the extent of peatlands (approximately 515,000km^2) have been produced by combining information from soil maps of Europe and topsoil organic content (Montanarella *et al* 2006) and information from the EU CORINE land cover (CLC) map for 2000 [(x)].

Much is known about the classification, ecology and palaeoecology of our peatlands, but recently there has been an increasing emphasis on understanding peatland function, particularly with respect to wider environmental processes considered under the general heading of 'ecosystem services'. 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 (Defra 2007, 2010). 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 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 work aims to provide the context to other topics currently under consideration by the IUCN UK Peatlands Inquiry, by discussing and comparing interpretation of the concept of peatland and 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 utilise peatlands.

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

- Support compliance with international monitoring and reporting obligations;
- 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 and support cost/benefits assessment of peatlands;
- 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 two parts. The first part (section 2 to 5) 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 peatlands deliver. The second part (section 6 to 10) of this report outlines information available on the state of peatlands for each UK country 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 (page 61).

A glossary of key terms and definitions used in the UK to describe peatland soils and habitats types and conditions is also provided.

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 recognises inactive peatlands lacking current peat formation. Inclusion of the latter category is vital because inactive peatlands respond to management and environmental pressures to deliver 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 paleoecological and historical record contained in peat show that peatlands go through active and inactive periods during their development (Lindsay 2010). Favourable management can result in resumed peat growth (e.g. Lloyd 2006; Wichtmann and Joosten 2007; Waddington *et al* 2010).

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

- Vegetation typically associated with peatlands 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 on estuarine sediment, tufa forming systems), and so have not been used to indicate peatland;

- The Ramsar definition would exclude peatlands where a former 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 such areas 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 and paleo-environmental 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 rate of input of organic material from the surface exceeds the rate of decomposition and 'turn-over' of this new material. 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 content of peat, it is much less dense than any other soil materials, with most of its 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% for 'peat'. Soil with peat layers typically have dry bulk densities ranging from between 0.06g cm^{-3} to 0.4g cm^{-3} depending on the level of humification, compaction or mineral content. Lindsay (2010) has reported that, in the UK, the typical carbon content of peat is 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 thus leave it prone to erosion by wind and water (Dekker and Ritsema 2000). If peat ceases to be waterlogged, decomposition is no longer retarded and the peat gradually decomposes. 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. The origin and quality of the water supply are important determinants of the broad type of peatland that develops. Interactions between geology, soil properties, topography and climate also strongly influence the peat formation.

Peatlands which receive all their water from precipitation are **bog peatlands**. Where such peat forms across a hilly landscape it is known as a **blanket bog peatland**. In the lowlands, such bogs can form on wet floodplains or in basins, often on the surface of existing fen peats, and because they rise up slightly above the surrounding landscape are known as **raised bogs**. Those which formed under the influence of ground- and/or surface-water supply 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 grade into fringing 'lagg' fens.

Raised bog- Flanders Moss NNR (Scotland)

Blanket bog - The Flow country (Scotland)

Poor fens basin mire - Anglesey (Wales)

The character of peat-forming vegetation strongly influences the character of peat soils. Peat soils formed from bog mosses are 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 exhibiting a two-layered structure (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 and peat 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, and based upon this a typology ideally suited to assessing a wide range of hydrological impacts.

2.2 Defining peatland - the different approaches

The Ramsar definition of peatlands is internationally accepted, but some assessments of peatland extent in the UK pre-date the Ramsar definition. There are key differences in the approaches that have been historically used in UK to define and delineate the peatlands. For example, definitions of peatlands have been based on soil and geological description and definition, or inferred from information on vegetation description and hydrological processes. Past and current approaches to defining and recording these different features have implications when assessing the extent and state of peatlands.

2.2.1 Soil-based definition of peatlands

Peatlands have been most commonly 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 Soil Survey Institutes sought to adapt existing classification systems to describe 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 exceeding 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 has been extensively used by the 2008-09 Defra 'Partnership Project to Protect and Enhance Peat Soils' [(x)] but different terminology and thresholds apply across the UK. In this report, the term 'deep peaty soils'

will be broadly equivalent to the Scottish definition of 'peat soils' and 'shallow peaty peat' equivalent to the Scottish 'organo-mineral soils'. Note that the term deep peat in Scottish classification is used to describe soil with a peat layer more than 1 meter deep.

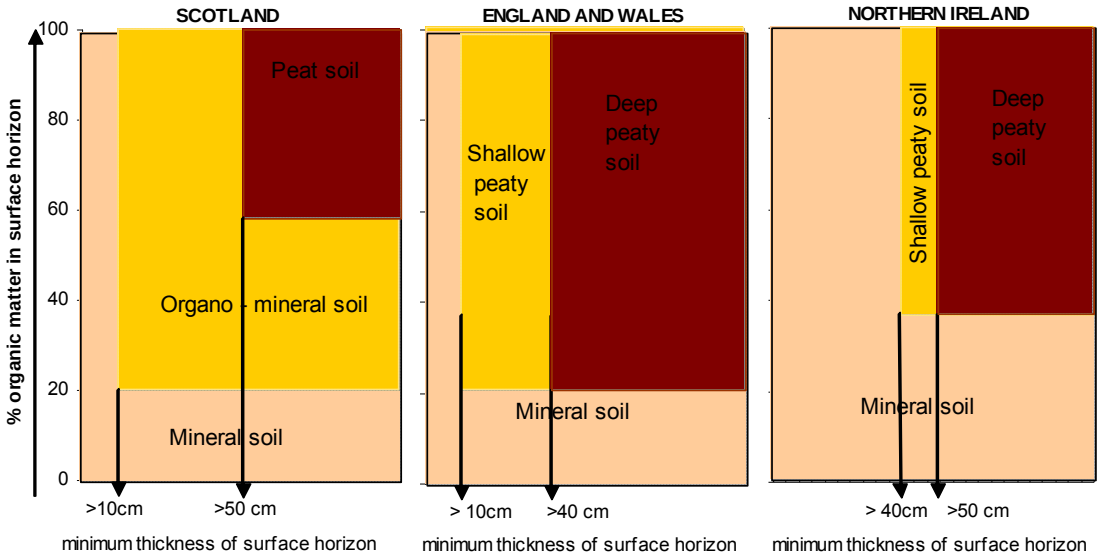


Figure 1. Minimum depth and % organic matter content threshold used for differentiation between mineral, peaty (organo-mineral) and peat soils in Scotland, England and Wales, and Northern Ireland soil classification schemes.

Recent work towards a harmonised international standard in soil classifications has led to the development of the World Reference Base (WRB) soil classification [(x)]. This system is now used by EU institutions for reporting on soil conditions and has been used to derive 1:1,000,000 soil and risk maps in Europe. It identifies soil by the presence of diagnostic horizons but does not record the depth of the peat layer. There is some correlation between 'histosol' type (characterised by more than 40cm 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. Soils in the UK have never been mapped with these definitions in mind and WRB maps are a reinterpretation and translation of UK national soil maps.

Consensus on classification and definition is not essential as long as information is collected and mapped in a consistent manner that enables cross checking to existing reference systems.

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 peatlands. It should be noted that this definition of peatlands also includes areas that are bare or supporting vegetation that currently does not form new peat.

Surveys of peat-forming vegetation are undertaken for biodiversity purposes and not specifically for determining the extent or condition of peat soils. However, where soil surveys are based on information from soil pits and auger samples, the extent of soil types between sample points 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 types found on peatlands is given in section 4.1.

Sphagnum moss

Cotton Grass at Kirkconnell Flow, NNR

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 1000s 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 has 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); 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 considers together vegetation, morphological and hydrological characteristics to define the range of functioning peatlands (e.g. Lindsay 1995, 2010; Wheeler *et al* 2009). Such schemes offer a potentially sophisticated understanding of peatland function and provide an important means to both evaluate sites for statutory protection and also for understanding the potential of management and restoration to restore active peatland.

Information on peat functions can be derived from the interpretation of soils/ geological and vegetation data. For example, information on peatland hydrology function has been derived from the Hydrology Of Soil Type classification (HOST) (Boorman *et al* 1995) which is based on the physical properties of soils and their effects on the storage and transmission of soil water, but which does not include consideration of vegetation cover. HOST Peat class information was taken from the 1:250,000 soils maps in the case of England, Wales and Scotland and the 1:50,000 soil maps in Northern Ireland. The presence of peaty surface layers (defined as having more than 20% of organic matter) is one of the soil properties used in the HOST classification.

Similarly, information on peatland carbon storage can be derived from models of bog peat depth. Peat depth modelling in relation to climate and topography has shown 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.

3 Sources of data / information on peatlands

This section reviews the data sources available to indicate the location and extent of peatlands and describes how these have been used to draw conclusions about peatland coverage. Mapping of peatland vegetation, management and function is described in section 4.1.

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, which were largely 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 experimental manipulation sites; these sources provide information on the processes and dynamics of change in peatland ecosystems and inform judgements of the state of the peatland resource; and
- Soils, biodiversity and environment monitoring schemes, which provide information on trends in state of peatland interest but are often point-based and cannot be used to map peatland extent.

Depth of the peat layer is a key part of peatland classification in the UK; consequently, any actual peat soil maps will help indicate the location of peatlands, and vice versa.

In recent years, many soil research activities have been driven by the policy requirement to understand and quantify the state and functions of UK soils and their responses to climate and environmental changes. These have given rise to different methods to represent similar information in the various UK countries. There has been increasing activity to understand the extent and location of organic-rich soils (referred as peat or peatlands in many policy statements); the ECOSSE project to improve our understanding of carbon storage and carbon emission from carbon-rich soils in Scotland and Wales (Scottish Executive 2007) is a prime example. More recently, the Scottish Government held 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* 2009a) and in England, Wales and Northern Ireland, data on peat location was collated to define the scope of the Defra 'partnership project to Protect and Enhance Peat Soils' [(x)]. The NERC EA-QUEST programme [(x)] also gathered peatland location information in order to explore potential climate change impacts in the uplands (Gallego-Sala *et al* 2010).

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.

3.1 Peat survey, databases and point sources information

3.1.1 Large-scale 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. This was also used as an assessment of 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). This information, together with data from the peat survey maps, commercial extraction surveys and Forestry Commission site survey reports was geo-referenced in the National Soil Inventory of Scotland (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 survey 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 (Money and Wheeler 1995; Shaw and Wheeler 1995; Shaw and Wheeler 1997; Shaw *et al* 1998). The NPRI covers the whole extent of deep peat within Britain (excluding Northern Ireland). The report includes 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, 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 with the aid of ground truthing) from the then most recent aerial photographs and mapped onto 1:10,000 sheets and subsequently digitized.

3.1.2 National soil database and countrywide soil data

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 maps. 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* 2009a). Similarly in Northern Ireland, 5km grid samples were taken during the life of the survey (1988-97), with resampling occurring in 2004/5.

The Countryside Survey [(x)] is a stratified random monitoring scheme which provides a national network of sites across Great Britain, representing the main types of landscape, land cover and soil groups. The Countryside Survey applies a rigorous, consistent methodology which includes characterising soil and vegetation. Unfortunately, restrictions mean that it is not possible to identify locations of sampling points with sufficient accuracy to relate these to mapped areas of peatland. Furthermore, the analyses of soil characteristics and broad habitat data available are only comparable at the scale of the 1km squares within which they are measured; and the soil data only refers to measurements in the top 15cm of soil, and cannot be used to infer information about peat depth. Notwithstanding these limitations, it is possible to use these data to identify those 1km squares which are dominated by highly organic soils, and examine the cover of broad habitats in these squares, to give an indication of peatland land cover and, by inference, land use. Summary land use data within kilometre squares characterised by their soil organic matter are presented in

section 6 for Scotland, England and Wales. Data from the related Northern Ireland Countryside Survey has not been analysed for this report.

3.1.3 Thematic / site specific soil and peat deposit information

A considerable amount of data is now being gathered by organisations such as national parks and AONB authorities, as well as part of impact assessment of new planning development. There is an urgent need to ensure basic standards of consistency in terms of both data collection and storage, and also better coordination of effort. A number of administrative obstacles (OS copyright for derived data, software licensing issues etc) currently prevent this from happening.

Soil maps are also produced at various scales from surveys conducted for specific management purposes. For example the Forestry Commission has undertaken a systematic soil survey of many of its forest holdings resulting in 1:10:000 scale soil maps employed *inter alia* for Ecological Site Classification (ESC) decision support (Forestry Commission, 2003).

Soil and peat mapping produced for Environmental Impact Assessments for planning applications (particularly for windfarms) also represent a significant new source of data for many peatland sites but much of this data is not easily readily accessible or collated at a suitable scale.

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

3.2 Map and country wide information

Many of the UK's peatlands are complex mosaics of wetland habitats, have gradual transitions between soil types, are remote, may overlie different rock types, and are agriculturally of lesser importance than most mineral soils. This means that, with regard to soil survey, 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 (generally as 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 creates problems when assessing the extent to which peatlands deliver certain ecosystem services on broad geographical scales.

Information on the status of peat has often been derived from historical archives on land use and land management (Rodwell 1986; Harrison 2003). More recently, contextual information has been recorded at the time of soil survey. This included vegetation cover information and sign of erosion or damage to soil if present at time of observation. Erosion may be reported on soil maps as eroded soil type but this does not inform on the type and intensity of erosion affecting the soil units. Recent re-samplings of national soil survey are providing a new opportunity to assess changes in soil depth.

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

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 ('soil associations' 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 larger 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.

Soil mapping approaches seek to apply definitions of soils that are applicable to similar soils regardless of management. However, the impact of management on peaty soils is often so severe that it can change the soil's horizon structure, and the characteristics of these horizons. Continued drainage and agricultural use also results in soils with peat layers that have become thin, or mixed with mineral deposits below, a process referred to as "wastage". Where evidence of such practices was observed a time of soil surveys, it may be recorded on soil maps as a separate distinct soil series (e.g. Downholland, Peacock, see Burton and Hogdson (1987)) or as an additional features on existing features (eroded peat in Scotland). In addition, peat cutting on raised bogs has been recognised as a distinguishing feature of some series (e.g. Turbary Moor, Westhay, England).

Table 1 shows the equivalence between peat and peaty soils classes in the different systems adopted by soil surveys in the UK. 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 Defra 'Partnership Project to Protect and Enhance Peat Soils t' [(x)].

Depth of surface horizon and organic matter content are key parameters in all peatland definitions; therefore 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.

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 Association Crowdy 1 and 2 Adventurer's; Altcar	Northern Ireland classification Soil Map Unit 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 soils with pockets of deeper peat):	E&W soil classification Soil associations*: Wetton 2, Willingham, Malham 1, Midelney, Isleham 1, Laploy, 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

a Soil maps 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 characteristics of soil in Scotland can be accessed via the *Soil Indicators For Scottish Soils* (SIFSS) web link (x).

b Soil maps of England and Wales

The most detailed level of classification in the Soil Survey of England and Wales (Avery 1980) 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 distribution and extent of 297 soil associations across England and Wales. This resource does not indicate areas of deep peat soil series included within organo-mineral soil associations. Similarly, some of the deep peat associations also include organo-mineral soil components.

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).

c Soil maps 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. Information on soils in Northern Ireland is available via AFBI website (x).

d Peat functional maps

Because of the commercial value of peat as fuel material and horticultural product, and more recently as carbon store, there has always been an interest in improving our understanding of the depth of peat deposits as well as their spatial extent. These elements are related where soil maps have used depth thresholds to identify peat, but such maps cannot indicate variations in depth of the peat mass across landscape. An understanding of the spatial distribution of peat deposit is important, in particular, to understanding the total amount of carbon the peatland stores, as well as being of value in understanding the hydrology of the peatland and its potential to store important palaeo-environmental features.

Most attempts to estimate the depth of peat in the UK have assumed a standard depth for all peat mass and used simple assumptions on peat bulk density change over depth to convert carbon concentration measurement into carbon stock (e.g. Cannell *et al* 1993; Howard *et al* 1995; Milne and Brown 1997). More recent works have reassessed these assumptions to provide improve estimate of carbon stock.

Natural England (2010b) reviewed data on English peatlands to reassess typical peat depths and carbon storage capacity in mapping units indicating peat origin, cover, management, and condition. However, this report recognises the paucity of depth data from certain peat

types (especially deep upland peats) and age of some of the data used, and calls for a more comprehensive and wide ranging analysis of existing data and new coordinated surveys.

In Scotland, the resampling of the National Soil Inventory and recent related projects have greatly improved understanding of Scotland's peat depth, their bulk density and enable revised estimate of soil carbon storage (Scottish Executive 2007; Chapman *et al* 2009b).

3.2.2 Geology mapping

The classification scheme for natural superficial deposits of Quaternary age (traditionally described generically as 'drift') was developed by British Geological Survey (BGS) to provide UK-wide 1:10000 scale maps. The scheme identifies a broad class of 'organic deposits' 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). The terminology of the scheme 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 such as deep or buried peat, and does not include peat deposits that occur entirely within 1 metre of the ground surface (McMillan and Powell 1999). Hence the map of 'peat deposit' is not a proxy for peatland extent and underestimates of the extent of UK peatlands (e.g. in the western parts of Northern Ireland and Wales). The 1:625,000 scale UK geology map is freely available for download from the BGS website [(X)].

In Northern Ireland, historic peatland extents are also been 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 recording of peat occurrence.

3.2.3 Habitat and vegetation mapping

Habitat and vegetation mapping generally provides good information on peatland extent. For example, blanket bog, raised bog and the core bog plant communities are generally associated with peats greater than 0.5m deep, and some forms of mapping (notably Phase I Habitat Survey, JNCC 2010) employ peat thickness as a mapping criterion.

Mapping of peatland habitat and vegetation cover is provided by either ground-based surveys at a range of scales or remote sensing. The main information sources are given in Appendix 1.

The UK Land Cover Map (LCM) 2000 (CEH) [(x)] uses satellite-derived imagery to identify land cover across the UK which has then been subsequently grouped into 26 broad categories broadly referable to the UK Biodiversity Action Plan Broad Habitats classification. However, there are a number of known issues with accuracy of classification which limit its uses for mapping peatland vegetation; for example LCM2000's distinction of bog is based upon using other datasets for mapped peat depth where depth >0.5m, and does not include examples on shallow peat but with bog indicator species. A new Land Cover Map (based on satellite imagery from 2007) is currently being produced.

The information from the UK LCM 2000 was generalised and used to form the UK contribution towards the EU CORINE Land Cover Map for 2000 [(x)] produced jointly by the European Commission and EU Member States.

The Land Cover Scotland (LCS88) [(x)], produced between1987-1989, was the first census of Scottish vegetation. It used the interpretation of medium-scale air photograph covering the whole of Scotland, validated against field survey, to report on 127 different land cover types.

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 the 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, maps of UK BAP peatland Priority Habitats have been produced following country-wide Phase 1 survey (Blackstock *et al* 2010). At present there are no maps available of peatland Priority Habitats in Scotland.

The country conservation agencies hold a variable coverage of survey information on peatland vegetation from surveys undertaken of SSSI/ASSIs (Sites/Areas of Scientific Special Interest) and SACs (Special Areas of Conservation) [(x)]. Most of these surveys have been digitised.

In Northern Ireland peatland vegetation extent is available through CORINE, generated by the manual interpretation of LandSat imagery. The available imagery did not allow detailed division beyond exploited and non-exploited peat and the pixel resolution of 25ha does mean that smaller peatland areas were often excluded.

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, 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, as well as 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.

4.1 Peatland vegetation and land cover types

All peatlands in the UK have developed 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 land management influences and impacts 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 can be augmented by more detailed vegetation surveys.

Sources of information on vegetation and land cover relating to peatlands are given in Appendix 1.

4.1.1 Peat-forming vegetation

A suite of vegetation types are associated with wet conditions that are conducive to peat formation, and these 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. 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 NVC communities M17-20 define the core range of bog-plane vegetation in the UK, with the representation of the bog-pool communities (M1-3) varying in relation to climate and land management.

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, M10, M13, M14, S24) 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 (including S25, S26) develops at locations with relatively enriched substrates, including periodically inundated floodplains. Nutrient-poor, acidic water promotes a bog-like **poor fen** (including M4- M8 and 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.

Fen vegetation (Scotland)

Rich fen vegetation (Wales)

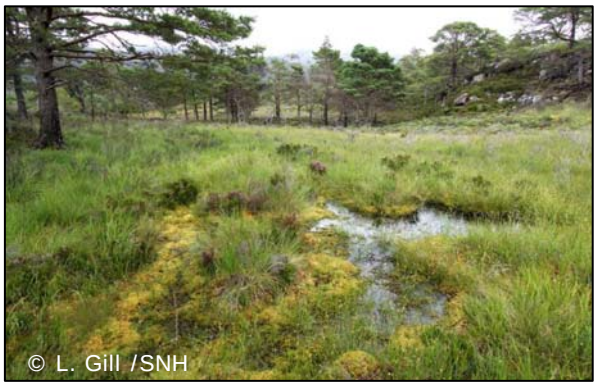
Many bog and fen vegetation types are recognised under the EC Habitats Directive as Annex 1 habitats (Council of the European Communities 1992) and as UK Biodiversity Action Plan Priority Habitats [(x)].

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 appears as sub-fossil remains in the palaeoecological record. However, the extent to which purple moor-grass-dominated vegetation is 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, but can also occur on deeper peats influenced by these factors.

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

Heather dominated Bog (Northern Ireland)



Pine woodland Bog (Scotland)

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 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 underlying mineral substrate. Eroded peat may be redeposited in basins, where it 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. This also leaves the peat surface bare for periods of the year.

Lowland fen (England)

Cultivated lowland fen peatland (England)

Forestry planting on peatlands usually results in a cover of coniferous trees, although fragments of original bog vegetation may survive in open areas. In the UK the main species planted are Sitka spruce (*Picea sitchensis*), 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 but not on peat.

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 also been built over with buildings, roads or other infrastructure, while others may have been removed for quarrying of the mineral resources beneath.

4.2 Degradation states of peat and link to peatland functions

Peatland characterisation has traditionally focussed on vegetation, hydrological and developmental criteria, but peatlands can also be described according to their degree of degradation. This can extend to consideration of 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 can also be applied to fens and recognises five categories of peat state / function (active, degraded, bare, archaic and wasted/lost). These are summarised below and their relevance to hydrological and carbon issues is in Table 2:

- **active peatlands** characterised as likely to be peat-forming because of the quality of the vegetation cover and largely unmodified hydrology. This may include formerly degraded surfaces in cases where management has successfully restored near-surface water levels;
- **bare peat** has had all its vegetation removed (e.g. by erosion) but has not been affected by a significant change of land use. This contrasts with **archaic peat** which may still have significant soil peat depth but is under other land use (e.g. cultivation);
- **wasted peat** has lost both its peat-forming vegetation and a significant depth of peat soil;
- All intermediate stages between active and bare peat are described as **degraded peat.** This resource retains a semi-natural vegetation cover, but with dominance either by graminoids or ericoids.

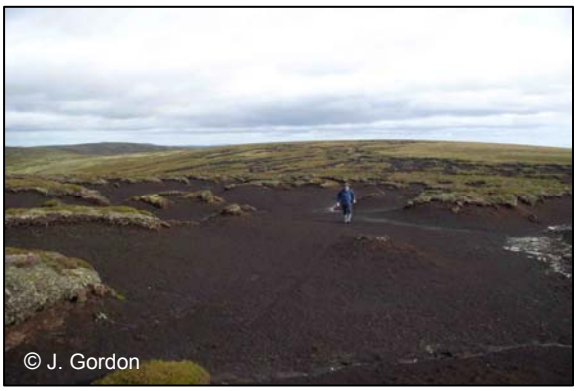
The location and extent of peatlands falling into the categories above are normally inferred from land management or vegetation information. Agriculturally wasted peatlands are thought mainly to occur in England, and can be indicated by the extent of a suite of soil types identified in the National Soils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

Moor-grips, Isle of Coll (Scotland)

Molinia-dominated blanket bog Rhondda Valley (South 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 loss of peat and significant dehydratation of adjacent in situ peat. 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.

Erosion- Lost peat (England)



Erosion - Bare peat (Scotland)

Natural erosion process of peat (especially blanket peat) can extend over large areas and remove large amounts of peat material. The geomorphology of peat damage is an important area of research in its own right.

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 Defra' Partnership Project to Protect and Enhance Peat Soils' [x] also provides information on extent of areas of hagged or gullied peatlands.

Peatslide, Shetland (Scotland)

Peat burst - Auchencorth Moss (Scotland)

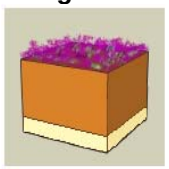
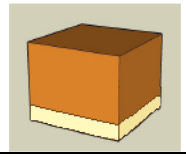
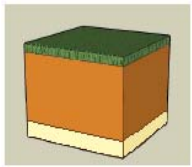
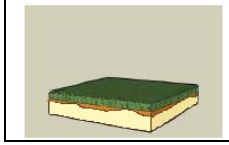
Peatlands are also subject to anthropogenic environmental pressures not directly related to site management, with atmospheric deposition of pollutants and climate change representing the key pressures. Deposition of nitrogen (as ammonia or nitric acid from nitrogen oxides) is an ongoing problem, but 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. Fen peatlands are also often affected by pollution of groundwater, particularly by plant macro-nutrients from agricultural fertilisers or domestic or industrial waste.

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 exceedence as shown in the UK Air Pollution Information System (APIS) [x].

Groundwater abstraction is a key pressure for some fen peatlands but groundwater impacts can also result from surface drainage and the resultant interruption of key groundwater supply pathways. Abstraction is an issue for some lowland raised bogs which are dependent on a high underlying groundwater table. Any alterations to the local hydrogeological regime can result in adverse impacts on mire hydrology and consequently conservation status and ecosystem service provision.

Climate change is one of the greatest threats facing our peatlands. A recent study (Clark *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 become more restricted geographically 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 or even bolstering 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 	• 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. • Optimal state for long-term storage of carbon in catotelm.
Degraded 	• Semi-natural vegetation, but with balance of graminoids/forbs/ericoids and bryophytes changed by adverse/lack of management. • Acrotelm absent or impacted. • 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 	• 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 	• No true acrotelm • Agricultural vegetation (grassland/ cropland) including cultivated land • Forestry where no bog flora remains. • Usually deep drained	• Water table controlled by ditch system, often with under-drainage • Held typically at ~40-80cm below peat surface in catotelm • 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 	• 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

The state of peatlands in the UK reflects their historical and on-going management for grazing land, fuel provision, nature conservation and more recently as a location for renewable energy schemes.

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 associated with delivering a specific set of ecosystem services, but which may also adversely affect other ecosystem services as well as 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.

Information on peatland land use and management can be based on extensive mapping of vegetation and land cover, or from similar information derived from a network of sample points. Data sources available for deriving land management are presented in Appendix I. This section describes the main land management practices relevant to UK peatlands. The wider implications for peatland ecosystem services are discussed in Section 5.

Some key land uses of peatland are described in the forthcoming National Ecosystem Assessment (UNEP WCMC, 2011). These land uses are briefly described here, along with some additional management practices affecting peatlands specifically.

Some peatlands are unmanaged, 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 peatlands are subject to some level of invasion by scrub and ultimately 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. Many peatlands remain impacted by past land management, such as drainage, or are influenced by other environmental factors, such as nutrient pollution, which promote graminoid dominance and the replacement of oligotrophic *Sphagna* by minerotrophic species or even hypnoid mosses.

Commercial peat extraction (Scotland)

Upland grazing (Scotland)

The most common land use for peatland is livestock grazing. Most active peatlands can only sustain light seasonal grazing due to the low productivity of the vegetation. Where there is too much 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 late 20th century because headage-based subsidy payments encouraged unsustainable stocking rates; 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 favours the deciduous purple moor-grass (*Molinia caerulea*), because winter burning only removes its dead leaves, but damages winter green plants such as hare's tail cotton-grass *Eriphorum vaginatum*.

Peat overburden removal (Northern Ireland)

Low land Cutting (Northern Ireland)

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 upland peatlands in the UK. 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 or exacerbate peat erosion. Ironically, the benefit of gripping in terms of increased agricultural productivity remains largely unproven (Stewart and Lance 1983). Some areas of upland peatland are affected in a similar way by the legacy of historic peat cutting for fuel, sometimes on a very large scale, although this practice is now restricted to predominantly small scale cutting in Scotland and Northern Ireland.

Forest plantation and Muirburn (Scotland)

Felling forestry, Bettisfield Moss (England)

Many upland peatlands are subject to grouse moor management. Regular burning (known as muirburn in Scotland) is used to enable artificially high populations of red grouse (*Lagopus lagopus scoticus*) by providing patches of older and younger common heather for

grouse food and nesting cover. This management replaces blanket bog with vegetation more akin to dry heath.

Upland peatlands, especially those with shallower peaty soils, are often 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 water table through dams or sluices to restore peat-forming conditions.

Windfarm on upland peatlands (Wales)

Cut over bog, Cors Goch Ceredigion (Wales)

Renewable energy generation represents a comparatively recent pressure, focussed predominantly on upland peatlands. Impacts include direct loss of peatland habitat through windfarm infrastructure overlap but also longer-term degradation, due primarily to the hydrological effects of tracks cut through or 'floated' over peat. These impacts are poorly quantified and there is a need for the industry to adopt consistent monitoring and investigation practices. A voluntary approach to estimate the impact of wind farm developments on the soil carbon stocks held in peats has been developed under contract to the Scottish Government (Nayak *et al* 2008).

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 service delivery 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 (2003) is now widely accepted as a framework to identify and categorised a range of services (Figure 2). It identifies four broad categories of ecosystem services;

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

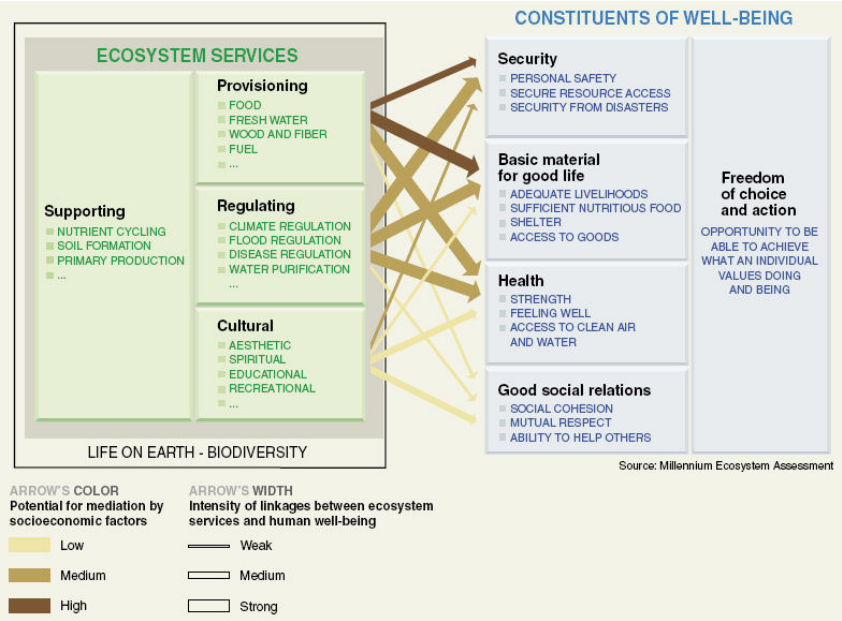


Figure 2. Ecosystem services linkages *(Source: extract from MA publication, "Living Beyond Our Means: Natural Assets and Human Well-being").*

The on-going UK NEA project [(x)] is built upon this approach and will provide a comprehensive assessment of services by end March 2011. The draft NEA chapters, circulated for review, have already influence our assessment of the role of various habitats and their relationship with ecosystem services. The following section builds upon evidence provided in the 'Mountains, Moors and Heaths' and 'Freshwater, wetland and floodplains' chapters to illustrate the main issues arising from peatland management. This report reflects the authors' expert knowledge and assessment of the current state of understanding and is not a definitive assessment of process interactions. Table 3 is an attempt to summarise the contributions an active peatland makes to delivery of a wide range of services, based upon information provided by the current development of the UK NEA. 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 services provided by different types of habitat associated with peatlands. (*Adapted from UK NEA draft reports)* (values range from - Negligible to +++ High) with modification to values based on expert judgment.

	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. *(Adapted from UK NEA draft reports.)*

		Gripping	Burning	Overgrazing	Afforestation	Abandonment	Peat Cutting (Fuel)	Peat cutting (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	Crops livestock & 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	≈	≈	≈	▲	▲	≈	≈	▲*?*	▲*?*
	Cultural heritage	≈	▲	▲	▲	▼	▲	▲	▲	▲
	Aesthetics	≈	≈	▼	▼	▼ / ▲	▲	▼	▼ / ▲	▼*?*
	Social Cohesion	≈	▲	≈	≈	▼	▲	▲*?*	≈ / ▲	≈ / ▲
	Tourism and recreation (grouse and game)	≈	▲	≈	▲	▼	▲	▼	≈	≈
	Education	≈	▲	≈	▲	▲	▲	▼	▲	▲
Support	Soil formation	▼	▼	▼	▼	▼	▼	▼	▼	▼
	Nutrient cycling	▲	▲	▲	≈	▲	▲	▲	▲	▲
	Biodiversity	▼	▼	▼	▼	▲	▼	▼	▼	▼[1]

[1] An increase or decrease of any given ecosystem function does not necessarily equate to an improvement or deterioration of the system overall.

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

Peatlands are clearly an important element in the UK's natural capital, and are of great importance to biodiversity, carbon storage, palaeo-archaeology, water quality, flood control, agriculture and as a strong feature of the UK's geomorphology, landscape and cultural identity. It is therefore important to understand the extent and location of peatlands within the UK, so that policies and initiatives which seek to protect or optimise these functions can be given the correct priority, based on an overview of the extent and location of our peat deposits. The ability of peatlands to deliver these services is influenced strongly by their management, which also influences their vegetation cover, and by external environmental pressures. The management of peatlands is amenable to change through the activity of land managers, policy makers, and the general public. It is therefore of vital importance to understand the extent of different land managements currently, in order to understand their ongoing impacts. This understanding should also enable better decision-making in respect of peatlands balancing the demands on them against their intrinsic value and function.

In the second part of this report, the information that is available on location and extent of peatlands first at a UK level and then for each country is reviewed. 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.

The first part of this report showed that there are fundamental differences in how peatlands are defined, characterised and mapped in the UK and at country levels. With the present state of knowledge, it is not possible to provide information on the extent of peatland and peat cover types that is compatible at UK level.

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

For example, in England, the Defra 'Partnership Project to Protect and Enhance Peat Soils' [(x)] 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 and Wales, the ECOSSE project 'Estimating Carbon in Organic Soils - Sequestration and Emissions' (Scottish Executive 2006) refined estimates on peat depth and soil density to developed maps which identify 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.

Whilst a two dimensional map tells us where we are likely to find peat deposits, it is only by understanding the true extent of peat deposits in the third dimension - the peat depth -that informed estimates of the importance of peat for carbon storage, an understanding of its hydrological function, and the its potential historic environment interest can be achieved.

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 to 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.

There is little direct information on trends and changes in peatland extent. The main sources are NSIS and NSI data on changes in soil properties, 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 in cover of the peatland Priority Habitats taken from the BAP reporting. The summary trend data are based largely on expert judgement. Where available, data for each country are provided in later sections.

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

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

The condition of designated habitat features 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 are the most comprehensive available by 2005, but incomplete coverage means they only provide 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, further complicates comparison across the UK.

Condition assessment is undertaken at country level and the country conservation agencies are reporting as complete coverage is achieved. So far information has been published for England (NE 2008), Scotland (SNH 2010) and Northern Ireland (NIEA, 2008). It should be noted that although each country bases condition assessment on the JNCC Common Standards Monitoring Guidance for Upland Habitats (JNCC 2009) and for lowland wetlands (JNCC 2004), all use different survey and reporting methods and so direct comparison of results between each country must be undertaken with caution.

Table 6. Condition assessment of core peatland habitat features on designated sites in the UK (SSSI in GB, ASSI in Northern Ireland), showing the proportion of sites in favourable or unfavourable condition. (Source: JNCC Common Standards Monitoring for Designated Sites: First Six Year Report [x])

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%

Condition assessment is used to fulfil the requirement to report 6 yearly on Annex I habitats under the EU Habitats Directive Article 17[2]. The 2nd report submitted to the European Commission in 2008 reported on the Favourable Conservation Status of Annex I habitats for the first time (JNCC 2007). Across the EC Member States habitats within the 'Bogs, mires and fens' group, is reported as being especially threatened and have the largest proportion of assessments reported as unfavourable-bad of any habitat group (EU 2009). All nine UK Annex I habitats in this group were considered to be unfavourable-bad. Other Member states reported bog, mires and fens habitats mostly as unfavourable bad or unfavourable-inadequate within the Atlantic bio-region and a slightly improved picture in the other bio-regions.

Countryside Survey soil and habitats data can be used to infer information on the distribution of habitats types on peatlands. The 2007 relative distribution of habitats type is shown for GB countries in Figure 3 for surveyed squares with more than 65% mean soil organic matter in their top 15cm (possible peat soil) and for surveyed squares with between 20 -65% mean soil organic matter (possible peaty or organo-mineral soil). Due to the low number of recorded survey square where soil samples were taken, these figures can only be used as indicative of the differences in Soil Organic Matter (SOM) between Broad Habitat types across GB. It must be borne in mind that these sample squares may cover considerable areas of shallower organic soils, and will also support considerable areas of mineral soils, as well as deep peat.

These data indicate that while around 25% of the survey squares in Great Britain with the most organic soils (0-15 cm) are dominated bog type habitats, this rises to 40% when including fens and heath habitats. Less organic square still retain around 9% of bog habitats. The ratio between % bog habitat on organic soil (0-15cm) and organo-mineral soil drops from 0.42 in Scotland to less than 0.25 in England and Wales and may be indicative of more damage peatlands. In England, the ratio between arable and improved grassland %

[2] Habitats Directive Article 17 Report (2001 - 2006) part of the web-based Article 17 Technical Report (2001-2006) http://biodiversity.eionet.europa.eu/article17 compiled by the European Topic Centre on Biological Diversity for the European Commission (DG Environment).

coverage on CS square with high (>60% SOM) and moderate (20-60% SOM) is 1.1 whereas in Scotland the ratio increases to 1.8. Those results are very similar to shown in the 1998 Countryside Survey for England and Scotland, but not data from Wales. This is likely to result form an increase in number of grid samples in Wales in CS2007 rather than significant land use cover change.

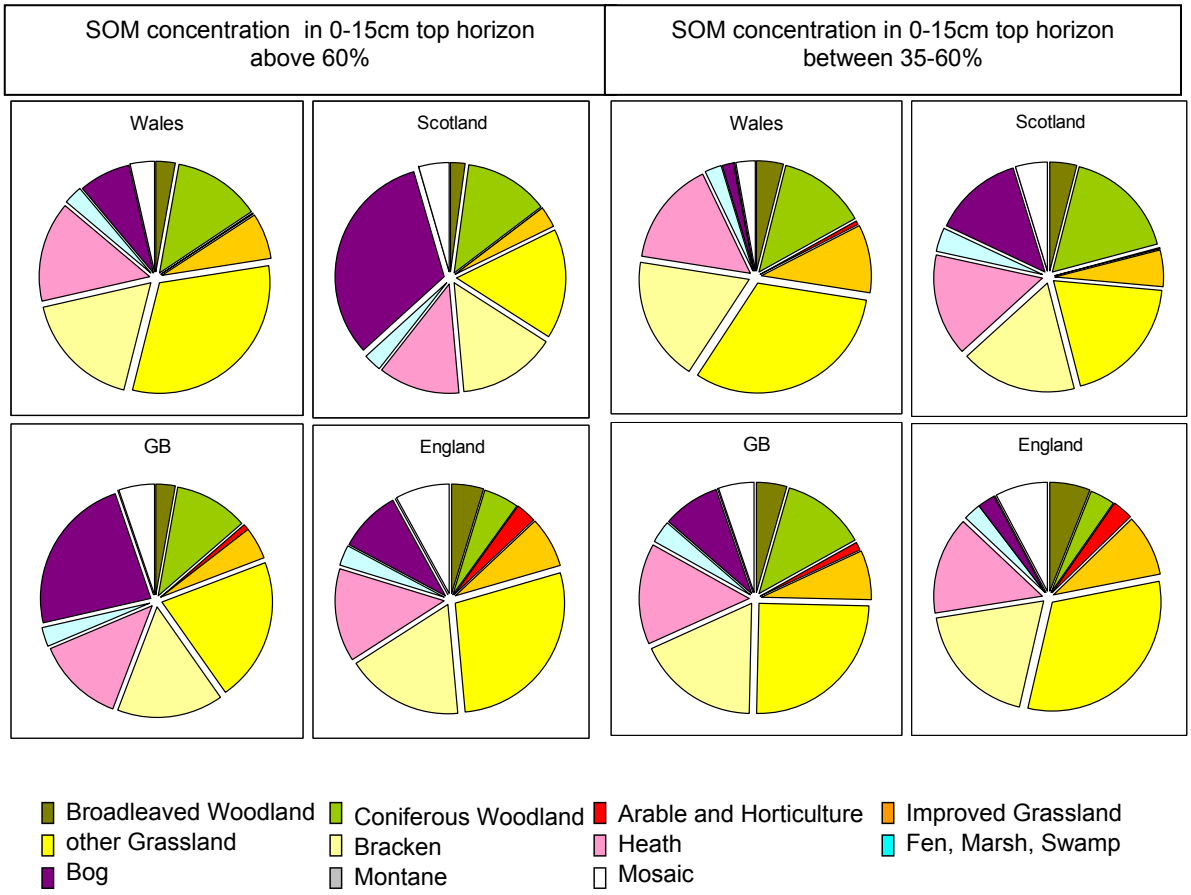


Figure 3. Countryside Survey 2007 Habitat as percentage cover for surveyed site with soil organic matter above 65% and between 20 and 65% in the 0-15cm horizon. *(Adapted from Countryside Survey © Database Right/Copyright NERC - Centre for Ecology & Hydrology. All rights reserved.)*

In conclusion, the peatlands of Great Britain appear to continue to support a significant cover of bog habitat, although almost half of this area is likely to be degraded in some way. Acid grasslands, upland heath and coniferous forestry are also important land covers in peatlands

Most of the information available on UK peatland 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 now creates difficulties in having a common understanding and language on information about the state of peatlands. For example, the concept of shallow peat is applied differently between England & Wales and Northern Ireland, and is not formally recognised in the soil classification for Scotland (see Figure 1).

Differences in vegetation descriptions also complicate assessments of UK peatland. Values reported for the extent of Broad and Priority Habitats are highly dependent on vegetation

definition, methodology, and scale of reporting in each country. Accordingly, expert judgements are used to fill in key gaps in the following country sections.

There is limited information on state and trends as surveillance programmes and monitoring schemes on peatlands 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 (e.g. international reporting obligation on protected sites). Such information is very useful within its context but cannot always be used to provide a national assessment of peatland state and change.

7 The location and state of peatlands in England

England's peatlands are mainly distributed across the uplands of the Pennines, with other upland areas such as Dartmoor, Exmoor and the North York Moors also supporting significant areas of upland peat. In the lowlands, extensive raised bog deposits are found around north Cumbria, the lowlands of Lancashire and the Humberhead Levels, while fen peatlands are most extensive in the East Anglia and the Somerset levels. Mapping of peatland location and status in England was undertaken by Natural England as part of the Defra 'Partnership Project to Protect and Enhance Peat Soils' [(x)]. The results of this exercise are presented here and were published in a recent report by Natural England that links peatland management to greenhouse gas emissions and carbon storage (Natural England 2010b). Peatland location mapping was based on existing maps of surface peat deposits (NATMAP [(x)], DIGmapGB [(x)]) and some habitat information, while a wide range of local and national data sets were collated to indicate peatland land use, land cover and environmental pressures.

While these data represent the best available overview of English peatlands, the peatland location data are limited in their level of detail (for example, the digital soils map used is at 1:250,000 scale) whilst some of the BGS data is relatively old and only reflects deeper peat deposits. The mapping of many land uses or vegetation covers such as historic peat cutting or cover of purple moor-grass is subject to only partial coverage, and some of the data, such as that for ammonia deposition, is only available in 5km squares. The coverage of these data is also incomplete, and there is a considerable area where no site-specific data is available. The Land Cover Map 2000 [(x)] represents a more comprehensive source of land cover information and is the result of a consistently applied analysis spanning the UK. However, LCM2000 does not mapped peatland vegetation types with sufficient accuracy in many areas such as the unenclosed moorland which holds the majority of English peatlands. The LCM 2000 also does not have sufficient spatial resolution to record some important management or environmental issues (such as gripping, erosion, rotational burning or peat cutting) although some land uses can be inferred from the data.

As part of the mapping process described above, Natural England commissioned a study of aerial photographs taken during 2002-2007 to map the extent of key visible peatland status types within deep peat areas inside the Defra "moorland line". This has proved an inexpensive, yet valuable addition to our understanding of the extent of key upland management issues. This approach could potentially be expanded to cover shallower upland peatlands, for which such data are currently lacking. Improved interpretation of remote sensing data, such as employing "Random Forest" and other statistical techniques for interpreting remote sensing data, is likely to improve our understanding of vegetation cover (e.g. Peters *et al* 2007). The forthcoming publication of Land Cover Map 2007 should enable improved mapping of peatland vegetation than that based on analysis of the LCM 2000 data.

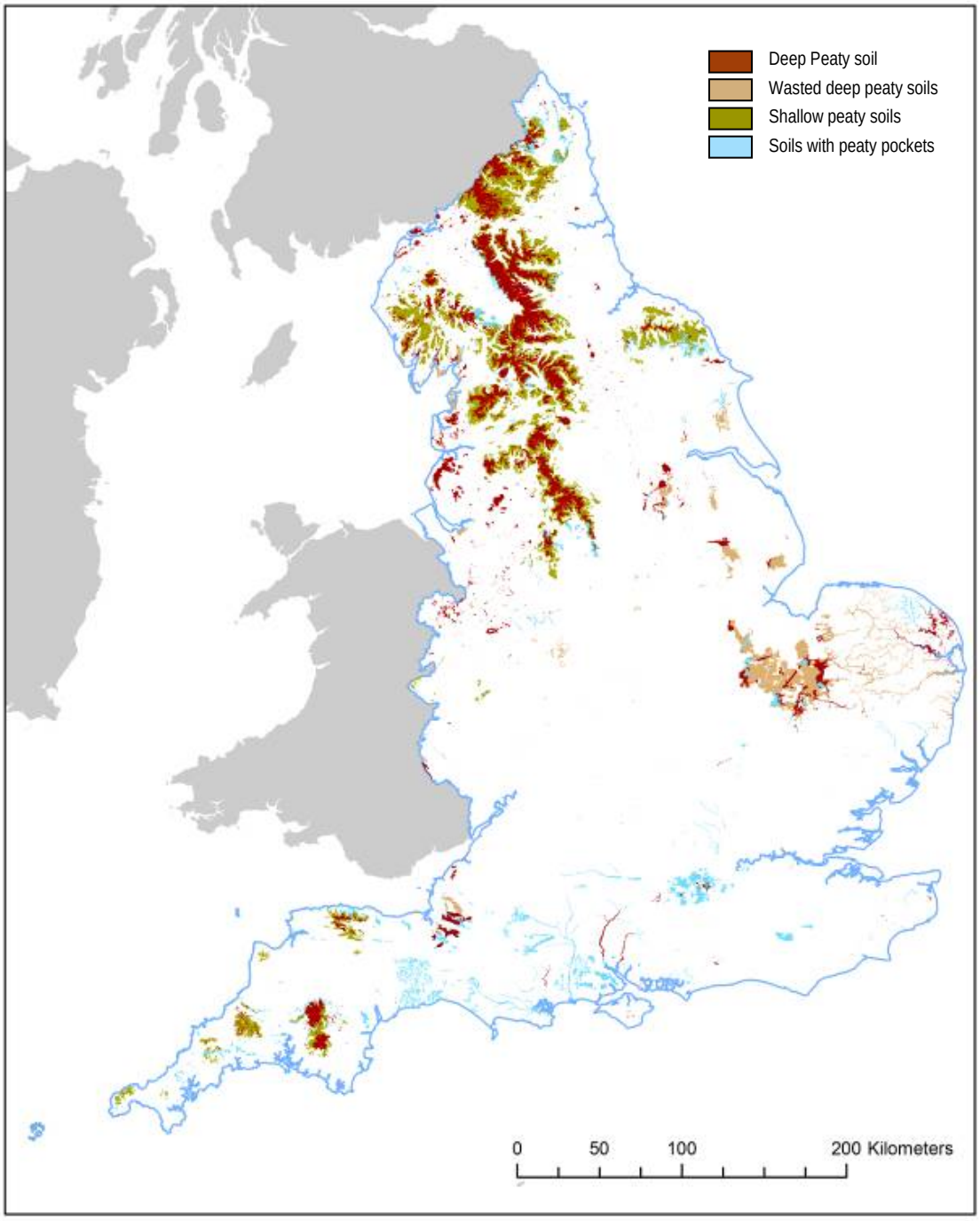


Figure 4. Location of deep peaty soils, wasted former deep peats, shallow peaty soils and soils with pockets of deep peat in England**.** *(Source: Mapping derived from 1:50,000 scale BGS digital data (Licence 2006/072, British Geological Survey © NERC). National Soils map © Cranfield University (NSRI) 008/09 BAP Habitat mapping (from OS derived data © Crown copyright. All rights reserved 2010. Natural England OS licence no. 100022021.)*

The approach taken by Natural England for assessing in the state of Peatland in England (Natural England 2010a) considers 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 *et al* 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 [(x)], British Geological Survey superficial geology data [(x)], and BAP Priority Habitat [(x)] mapping for Blanket Bog. Based on the mapping information presented in Figure 4, 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 192,403haof 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 characteristics (hagging and gullying) and ammonia deposition data, and used these data to inform estimates of peatland carbon storage and GHG flux. Figure 5 shows the land cover data collected for this report. Based on LCM2000 information and using peat soil maps as a filter, 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.

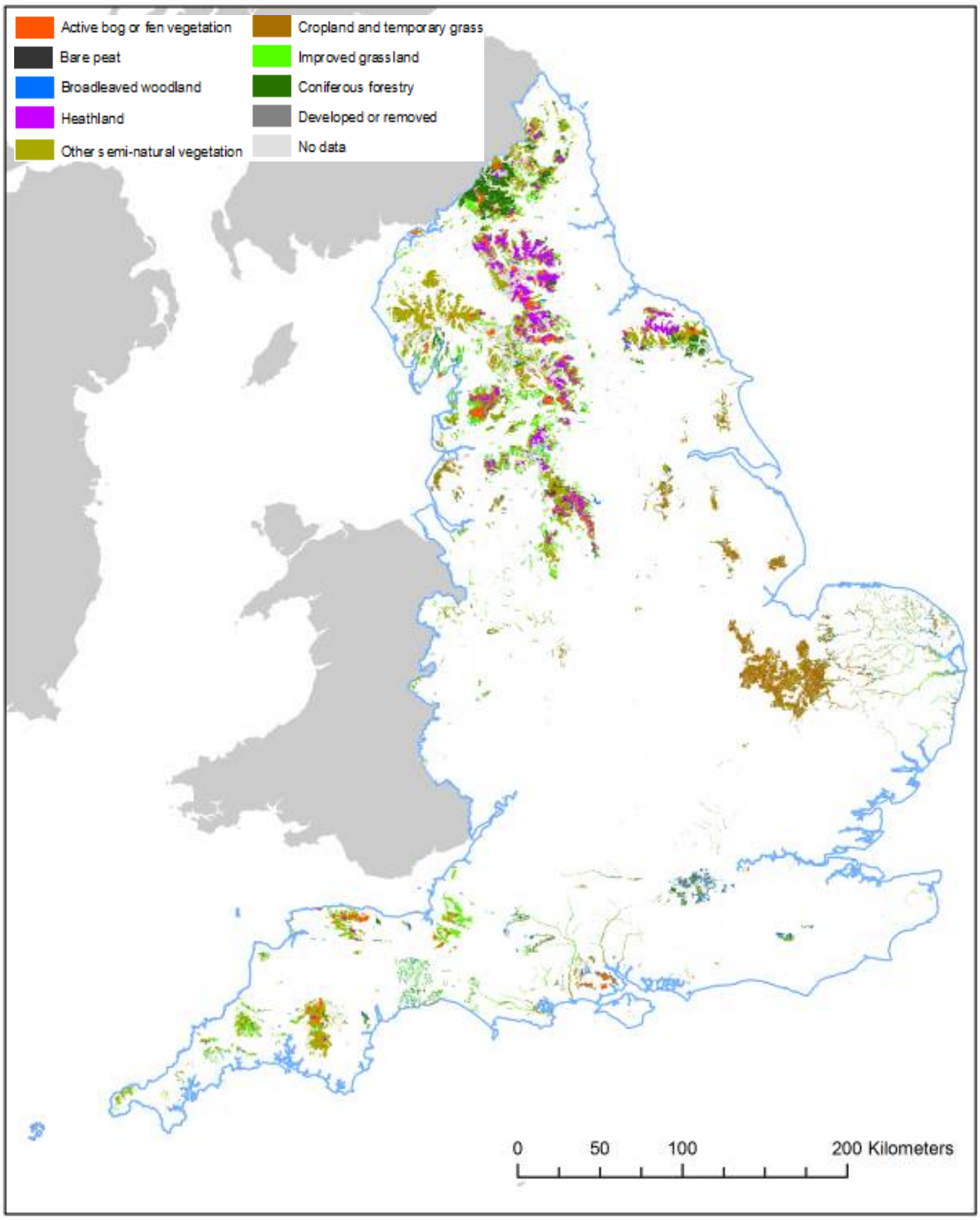


Figure 5. Vegetation and land cover of English peatlands (Natural England 2010b). *(Source: Mapping derived from 1:50,000 scale BGS digital data (Licence 2006/072, British Geological Survey © NERC). National Soils map © Cranfield University (NSRI) 2008/09 BAP Habitat mapping (from OS derived data © Crown copyright. All rights reserved 2010. Natural England OS licence no. 100022021.)*

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. *(Source: Natural England, data described in Natural England (2010b). Different classes may overlap to indicate land subject to several managements, covers and pressures.)*

	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. Different classes may overlap to indicate land subject to several managements, covers and pressures.

	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	**527,192**	**211,424**

The state of semi-natural peatlands in England has been reported upon recently through BARS (Biodiversity Action Reporting System). The 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(in ha)	Summary trend (from UKBAP 2008 Reporting)	Biodiversity Action Reporting System (BARS) links
Blanket Bog	255,308	Declining (slowing)	National action plan - Blanket bog
Lowland Raised Bog	17,411	Stable	National action plan - Lowland raised bog
Lowland Fens	8,000	Declining (slowing)	National action plan - Fens
Upland Flushes, Fens and Swamps	Not applicable	Not applicable	New Priority Habitat so not yet reported on

Table 11 presents results from the Countryside Survey data that have been used to infer change in peatlands habitats. There was no detectable change in the estimated area of Bog

Broad Habitat 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. *(Source: Extract from 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	

The condition of natural features on designated sites is monitored through Natural England's condition assessments and was reported in State of the Natural Environment 2008 report (NE, 2008). Condition assessment of peat forming habitats within designated sites in England has indicated that: 70% of blanket bogs; 60% fens; and 63% of lowland raised bogs were in favourable or unfavourable recovering condition (Natural England 2008).
There is a reasonable amount of data available on the extent and state of English peatlands. However, the data available on peatland location are mostly at a rather large scale, or indicate only deeper peat deposits, and few recent data are available to indicate peat depth, especially in upland peats. Data on vegetation cover and land management are good, but could be improved by analysis of more comprehensive data sources such as future Land Cover Maps. Data for deep peatlands in the uplands is more available than for shallower peatlands, and certain features, such as historic peat cuttings, are poorly mapped throughout.

On the basis of the available data, English peatlands appear to be predominantly semi-natural, particularly in the uplands, although only a small proportion of this area appears to support good quality peat forming bog vegetation. Almost a third of upland deep peatlands have been affected by rotational burning, a fifth by grips (drainage channels) and a seventh by erosion into haggs and gullies. Almost all bog peatlands are likely to be receiving more ammonia deposition than can be tolerated by bog habitats. These factors may explain the paucity of good quality bog vegetation in England's bog peatlands.

Although less data is available for some (particularly moorland) areas of shallow peaty soils, these also appear to support predominantly semi-natural habitats such as acid grassland, heath and bracken. However, they also appear to be more affected by agricultural improvement for grassland, and by coniferous forestry. However, there has been a recent trend of reducing cover of conifers in areas with peaty soils, and more mosaics of semi-natural habitat is likely to have been created on shallow peaty soils as a result.

Lowland peatlands have been strongly affected by agriculture, and little fen or raised bog habitat exist over their former range. While relatively little deep fen peat remains to be cultivated, cultivation extends over a very large area of wasted former peatlands. Almost two fifths of English raised bogs have been extensively "reclaimed" for agriculture and a further sixth is under coniferous forestry.

These data underline the importance of understanding the impacts of major land management types such as rotational burning, moorland drainage, cultivation and agricultural improvement on the ecosystem services delivered by peatlands in England. While some analysis has been presented on the likely impacts of these managements on greenhouse gas and carbon flux (Natural England, 2010b), more robust data are required to provide representative emissions factors that can be used to prioritise and reward improvements in peatland management. As well as their importance for climate change, these impacts of these land uses on other ecosystem services, such as provision of drinking water, flood mitigation and food production, should also be examined.

Restoration of peat-forming vegetation is a clear priority for peatlands in England, which compare poorly with those of Scotland in terms of the extent of bog habitat (Defra 2008). The benefits of peatland restoration for biodiversity are clear, in that this would create a suite of highly valued internationally important habitats. However, the success of restoration may be challenged by ongoing nutrient pollution of sensitive bog habitats. Given the scale of degradation of English Peatlands, and the scale of potential restoration, it is also important that we understand the impacts of restoration on other peatland functions. Some of these issues are addressed in the IUCN peatland inquiry reports on burning, hydrology and restoration.

8 The location and state of peatlands in Wales

Peatland habitats are widely distributed throughout Wales. Rainfall mostly well in excess of 1000mm per year coupled with an undulating and predominantly drift-mantled landscape have provided a wide range of contexts for peat formation. Blanket peat is by far the most widespread and extensive component, occurring throughout the upland spine of Wales from Snowdonia and Mynydd Hiraethog south to the Berwyn and throughout the Cambrian Mountains to the Brecon Beacons and South Wales valleys. Peat is also very widespread in the lowlands, though extensive areas are rare with the impressive lowland raised bogs of Cors Fochno and Cors Caron (Ceredigion) and Fenn's, Whixall and Bettisfield Mosses (Wrexham/Shropshire) being the best known examples. Smaller expanses of ombrogenous peat are very widespread, particularly as basin and valley-head deposits, and the same applies to fens and many swamps. Large (>50ha) expanses of fen are rare. Because of the modest extent of many of these areas of peat, conventional peat mapping gives the impression of a rather confined and dispersed resource at odds with the rich and diverse peatland heritage of the country.

Information on peat extent in Wales is available from a wide range of sources.

8.1 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 70,600ha (Table 12) and this is the figure used by the ECOSSE project. However, because this estimate is based on soil association level data it is likely to include over- and under-estimates of the resource depending on the extent to which:

- peat associations include organo-mineral or even mineral soil series, and
- '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). For example, the average patch size of lowland fens in valley and basin contexts in Wales is modest (4.1 and 1.5ha respectively; CCW unpublished data) but these habitats collectively cover 1900 ha. It is likely that a proportion of this resource is excluded from the Soil Map of England and Wales estimate.

Earlier estimates of the extent of peat in Wales indicate a more extensive resource than Table 12. For example, Taylor and Tucker (1968) provide a figure of 84,200 of peat >0.91m thickness, while Taylor (1983) estimates the Welsh peat resource as 158,770ha and also provides a map of deep (>0.5m) peat which indicates more peat in the south Wales uplands than the Soil Map of England and Wales. These differences are likely to be the result of methodological approaches, but they underline the importance of developing an improved information resource for peat extent in Wales. Additional impetus for this is provided by the stronger emphasis on the ecosystem approach and ecosystem service delivery embodied in the emerging Natural Environment Framework for Wales (Welsh Assembly Government 2010). This initiative will throw into sharp focus the need for reliable, spatially referenced data on peat extent and condition and its status in terms of both carbon storage and carbon sequestration potential. Gathering this information will require coordination of effort between the many different sectors in Wales with peat data holdings, and ideally would provide a common framework for accommodating the extensive data-sets on peat depth and distribution forthcoming from the many wind farm developments in Wales.

Table 12. Areas of different peatland types in Wales derived from soils, geological and habitat maps. Data reproduced from the ECOSSE study.

Mapping Class	Area (100's ha)	% Wales (%UK)
Peat Soils	70,6	3.0 (0.3)
Peaty Soils	359,2	17.3 (1.5)
All peaty soil types	42,98	20.3 (1.8)

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

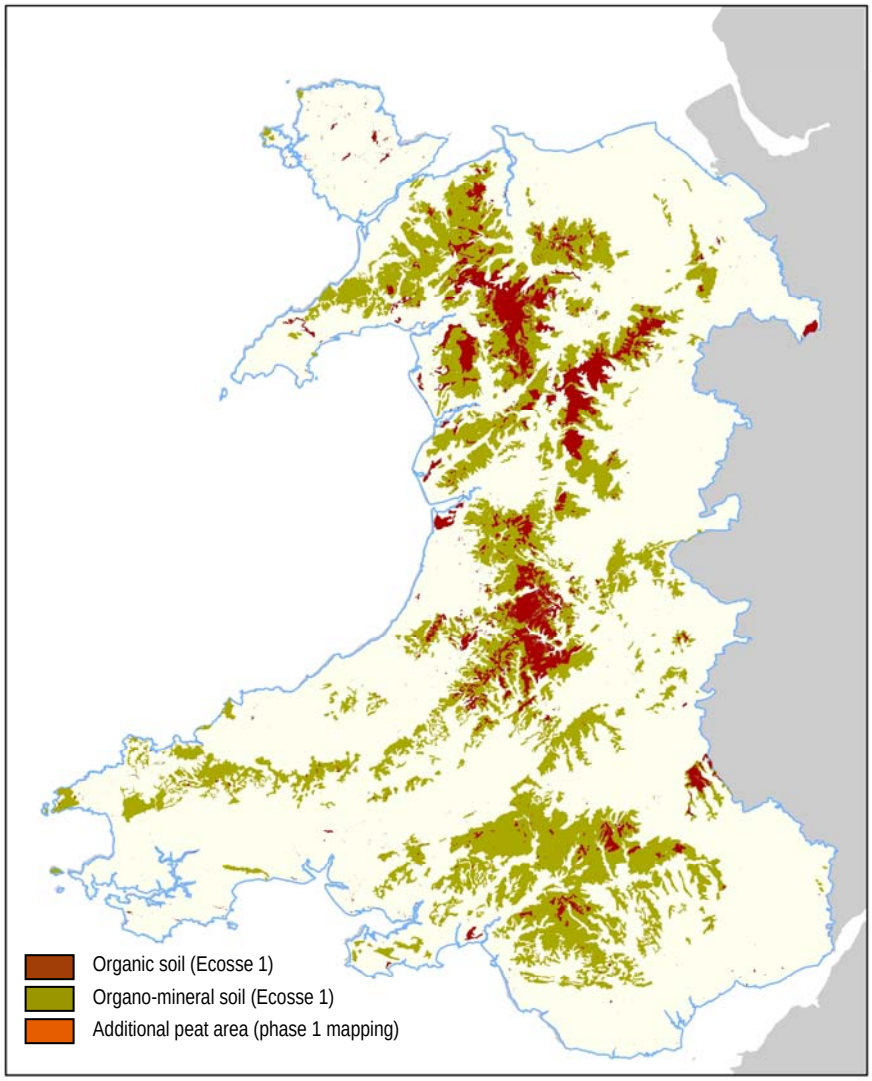


Figure 6. Location and extent of peatlands in Wales. Mapping of organic (deep peat) and organo-mineral soils from the ECOSSE project has been augmented by data on bogs and topogenous fens from the phase 1 map of Wales. Source: Soil Carbon data from ECOSSE Project (funded by Scottish Executive and National Assembly for Wales). Phase 1 Habitat data - CCW © Crown copyright. All rights reserved. Countryside Council for Wales, 100018813.

8.2 Extent of different habitat/land cover elements on peat

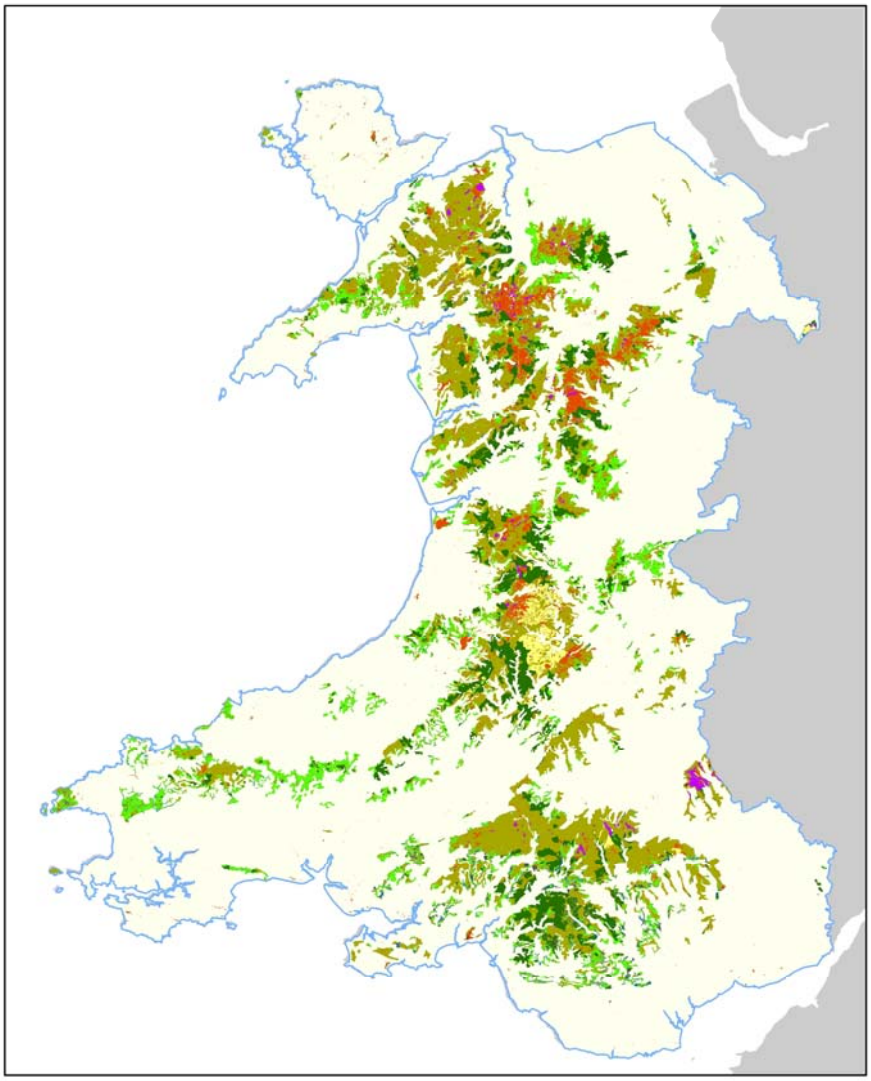
The Habitat Survey of Wales provides reliable information on peatland extent for bog and topogenous fen because field mapping of these categories was conditional on the presence of at least 0.5m of peat (Jones *et al* 2003, Blackstock *et al* 2010, Jones *et al* in press). The addition of these data to the soil survey results as interpreted by the ECOSSE project is shown as Figure 6 and provides an up-to-date assessment of the Welsh peatland resource.

The total extent of mire habitats recorded from the Welsh Phase I survey (CCW 2004) is shown below in Table 13. The sum total figure of 79,000ha is close to the 70,600ha 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. However, it is estimated that 12,400ha of woodland occurs on peats at least 1m deep, the majority of it (9,995ha) coniferous woodland (Van Velzen and Joss 2009). Significant areas of heath and acid grassland are also known to occur on peat, especially in the uplands. Archaic peat, typically under improved grassland, is principally associated with the major estuaries of the west coast. Taking all these land cover types into account, it seems very likely that the 70,600hafigure for deep peat soils in Table 12 is an under-estimate.

Table 13. Cover (ha) of habitats strongly associated with peatlands in Wales. Data derived from the Habitat Survey of Wales (Blackstock *et al* 2010).

Habitat type	**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
Total	10,100	68,800	79,000

Trends on changes in the extent of BAP priority habitats associated with peatlands in Wales are provided by the most recent (2008) BAP reporting round which showed a 'declining (slowing)' trend for blanket and lowland raised bog and a 'declining (continuing/accelerating)' trend for lowland fens. These trends relate to the mostly small-scale loss of areas of habitat outside the SSSI series, generally as a result of localised development pressure (including wind-farms) and agricultural intensification. More serious is the poor condition of many areas of semi-natural peatland habitats. Lowland fens suffer particularly from management neglect (chiefly lack of grazing) and diffuse enrichment, whilst marginal drainage in particular affects many sites. These issues also apply to many areas of lowland bog, with even key conservation sites such as the SAC raised bogs of Cors Fochno and Cors Caron still influenced by the dual effects of historic internal drainage and peat cutting, and continuing deep marginal drainage. Erosion resulting in bare peat is relatively confined.



Legend

- Bog and fen *sensu* Phase I, including active mire.
- Wet modified bog (including areas dominated by *Molinia*).
- Other semi-natural habitat - only partly peat-forming
- Scrub
- Broadleaved woodland
- Bare peat
- Dry modified bog and Heath
- Coniferous forest
- Cropland
- Improved grassland
- Developed or removed
- No data

Figure 7. Map of the habitat cover of peat and organo-mineral soils in Wales based on the Habitat Survey of Wales (Phase 1 data) (source: © Crown copyright. All rights reserved. Countryside Council for Wales, 100018813 2011.)

Several major peatland restoration projects are underway across Wales, with a marked recent emphasis on restoring the hydrology of gripped and afforested uplands mires resulting in large projects led by the RSPB, National Trust and Wildlife Trusts in north and mid Wales. Work to understand the consequences of restoration for greenhouse gas flux is accompanying a number of these projects, with significant research well advanced at Vrynwy (Berwyn) under the UK PopNet programme and a significant DEFRA funded study on the Migneint to examine how different grip blocking techniques influence methane emissions. A key remaining priority for the uplands is to tackle the large-scale domination of many areas of peat by *Molinia* (Yeo 1997).

In the lowlands, restoration effort is more localised though nonetheless intense, with a major LIFE project [x] underway for the Anglesey and Lleyn fens and major restoration projects on the three largest raised bogs. This effort needs to be expanded across a much wider suite of sites, with grazing support initiatives featuring as a key mechanism but also implementation of the Water Framework Directive to help counter drainage mediated groundwater impacts.

The state of semi-natural peatlands in Wales has been reported upon recently under the BARS process (Biodiversity Action Reporting System). Estimates on the extent and trends of peatland Priority Habitats for Wales are given in Table 14.

Table 14. Extent and trends of peat forming vegetation Priority Habitats in Wales.

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

Table 15 presents results from the Countryside Survey data that have been used to infer change in peatlands. The Bog Broad Habitat in Wales is mainly located it the uplands and shows no significant change in extent between 1998 and 2007 and no significant change in mean plant species richness score for Main Plots.

The Broad Habitat 'Fens, marsh and swamp' 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 extent of this habitat did not change significantly between 1998 and 2007.

Table 15. Countryside survey data for Wales, showing Broad Habitat extent. *(Source: 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 SIGNIFICANT CHANGE
▪ Upland	15	14	
▪ lowlands	24	22	
Bog			
Total Wales	45	48	NO SIGNIFICANT CHANGE
▪ upland	8	8	
▪ lowlands	36	40	

9 The location and state of peatlands in Northern Ireland

The sources of information on peatland extent, management and condition have been largely derived from the Soils Map of Northern Ireland (Cruickshank 1997), Northern Ireland Peatland Survey (Cruickshank and Tomlinson 1988, Landcover Map 2000 (CEH 2002), the Northern Ireland Countryside Survey 2007 (Cooper *et al* 2009) and detailed surveys and monitoring relating to designated sites.

There is good data on peatland extent showing that 24.6% (3,483km^2) of Northern Ireland is covered by peat (2,064km^2) or peaty soils (1,417km^2) being mainly found in the north and west of Northern Ireland.

Information on habitat, land cover and condition and trends is reasonable although incomplete. The data indicates that most of the peatland (1,609km^2) is covered with bog vegetation (comprising 1,398km^2 of blanket bog and 211km^2 of lowland raised bog) with a more limited area of fen vegetation (3km^2). There are significant areas which have been afforested and some agricultural reclamation.

Most blanket bog, lowland raised bog and fen has been impacted by peat-cutting, drainage and inappropriate grazing levels. These impacts have generally lessened in recent years, with blanket bog showing some signs of recovering condition (based upon NIEA condition assessment data for ASSIs - P. Corbett pers. comm.). However, the area and condition of lowland raised bog and fen is still considered to be declining significantly (NIEA ASSI condition monitoring reports and UK BAP report 2008).

Peatland habitat and land cover data requires further improvement. The Northern Ireland Peatland Survey uses aerial photographs which are now over 30 years old and more analysis or interpretation is being undertaken with the Land Cover Map 2007 and Northern Ireland Countryside Survey 2007. Information on carbon storage and sequestration is very limited or lacking.

9.1 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 8 shows the coverage of deep and shallow peaty soils, and soils with peaty pockets in Northern Ireland. Table 16 present the areas covered in Northern Ireland relative to the whole of the UK for deep peaty and peaty soils.

Table 16. Areas of different peatland types in Northern Ireland derived from soils, geological and habitat maps.

Mapping Class	Area (ha)	% Northern Ireland(%UK)
Peat Soils	206,400	14.6 (0.8)
Peaty Soils*	141,700	10 (0.4)
All peaty soil types	348,200	24.6 (1.2)

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

9.2 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; Cruickshank *et al* 1993), and these have been combined with additional data from the Land Cover Map 2000 (CEH 2002) to provide an indicative map of peatland land use and management in Northern Ireland (Figure 9).

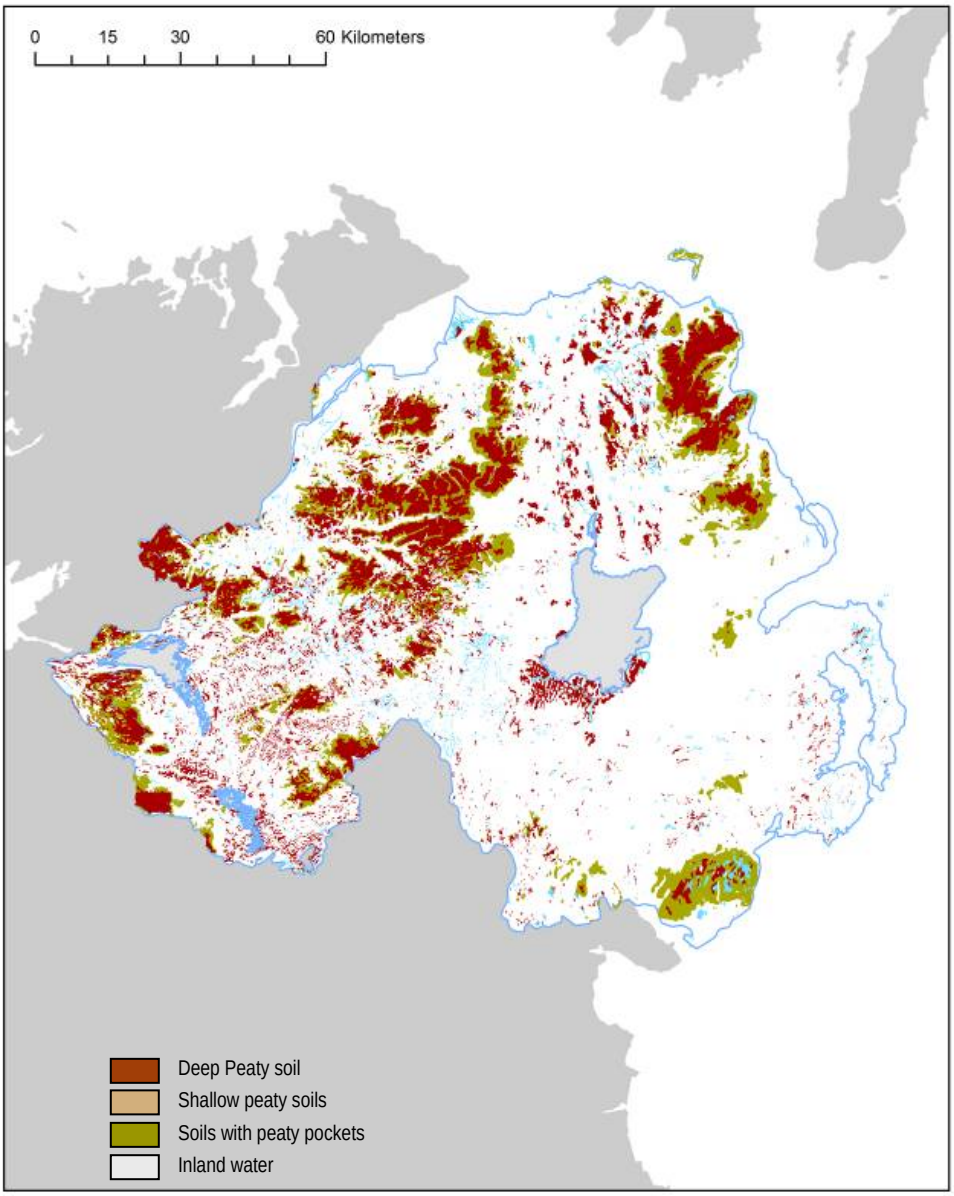


Figure 8. Deep and shallow peaty soils, and soils with peaty pockets in Northern Ireland. *(Source: Mapping derived from 1:50,000 scale AFBI digital data)*

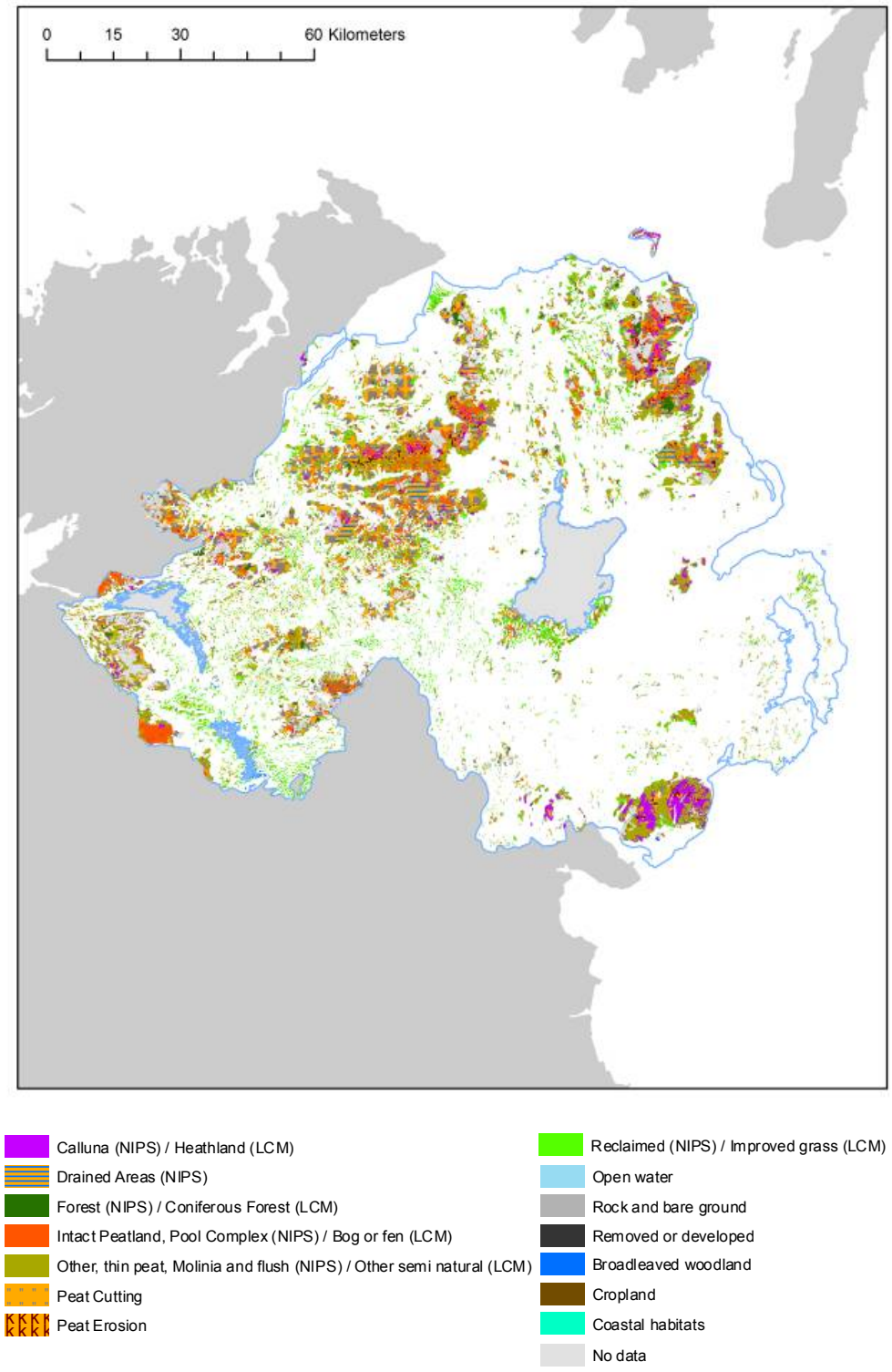


Figure 9. Peatland land use and management in Northern Ireland, based on the Northern Ireland Peatland Survey and Landcover Map 2000 (LCM) classifications. *(Source: Mapping derived from Soil Survey of Northern Ireland (Cruickshank, 1997). Peatlands identified by Agri-food and Biosciences Institute (AFBI), 2009, by Alex Higgins and Crawford Jordan. Peatland land cover and management information derived from the Northern Ireland Peatland Survey (NIPS, Cruickshank and Tomlinson, 1988) and the Landcover Map 2000 (CEH, 2002)).*

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 17.

Table 17. Extent and trends of the main peat-forming vegetation Priority Habitats in Northern Ireland.

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

Table 18 presents result from the Countryside Survey data that have been used to infer change in peatlands.

Table 18. Countryside Survey data for Ireland, showing Broad Habitat extent. *(Source: 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	164,216	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	

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 are no statistically significant changes in any of the component Primary Habitats, the main changes were losses of this Broad Habitat to the Bog Broad Habitat and to tree planting, primarily in the marginal uplands.

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 were loss to scrub succession at the edge of bog complexes, and losses as well as gains from the Neutral Grassland and the Fen, Marsh and Swamp Broad Habitats.

10 The location and state of peatlands in Scotland

Peatlands in Scotland extend over large areas of the Scottish uplands but are most extensive in the north and west in areas with gentle slopes and poor drainage. Blanket bog is one of the most extensive semi-natural peatland habitats in Scotland, covering some 1.8 million hectares, or 23% of the land area. Blanket bog is a rare habitat globally and Scotland holds a significant proportion of the European and world resource. It is the habitat that dominates the landscape of the gently undulating moorlands, particularly in the North Highlands and Western and Northern Isles. The peatlands of Caithness and Sutherland located across the northernmost parts of mainland Scotland form one the largest and most intact areas of blanket bog in the world. With its high rainfall and rugged, glaciated landscape, Scotland is also rich in wetland habitats, from isolated lowland bogs to the vast Insh Marshes near Aviemore and the lowland raised bogs in Scottish firths (Flanders Moss).

ECOSSE 1 (Scottish Executive 2007) and ECOSSE 2 (Smith *et al* 2009) and RERAD funding for soils research under Programme 3 provided a new model for organic soils and revised estimates for carbon stocks but nothing new on soil structure. The Scottish Government commissioned an expert workshop in 2009 to establish the current state of knowledge on extent and condition of Scottish peatlands (Chapman *et al* 2009a). This information was used in the preparation of Scottish Government's discussion paper on the Management of Carbon-Rich Soils (Scottish Government, 2010).

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.

10.1 Soil-defined peatland extent

The location and extent of Scottish peatlands is shown in Figure 10, while Table 19 details the coverage of different types of peatland soils in Scotland as expressed in the Soil Maps of Scotland dataset.

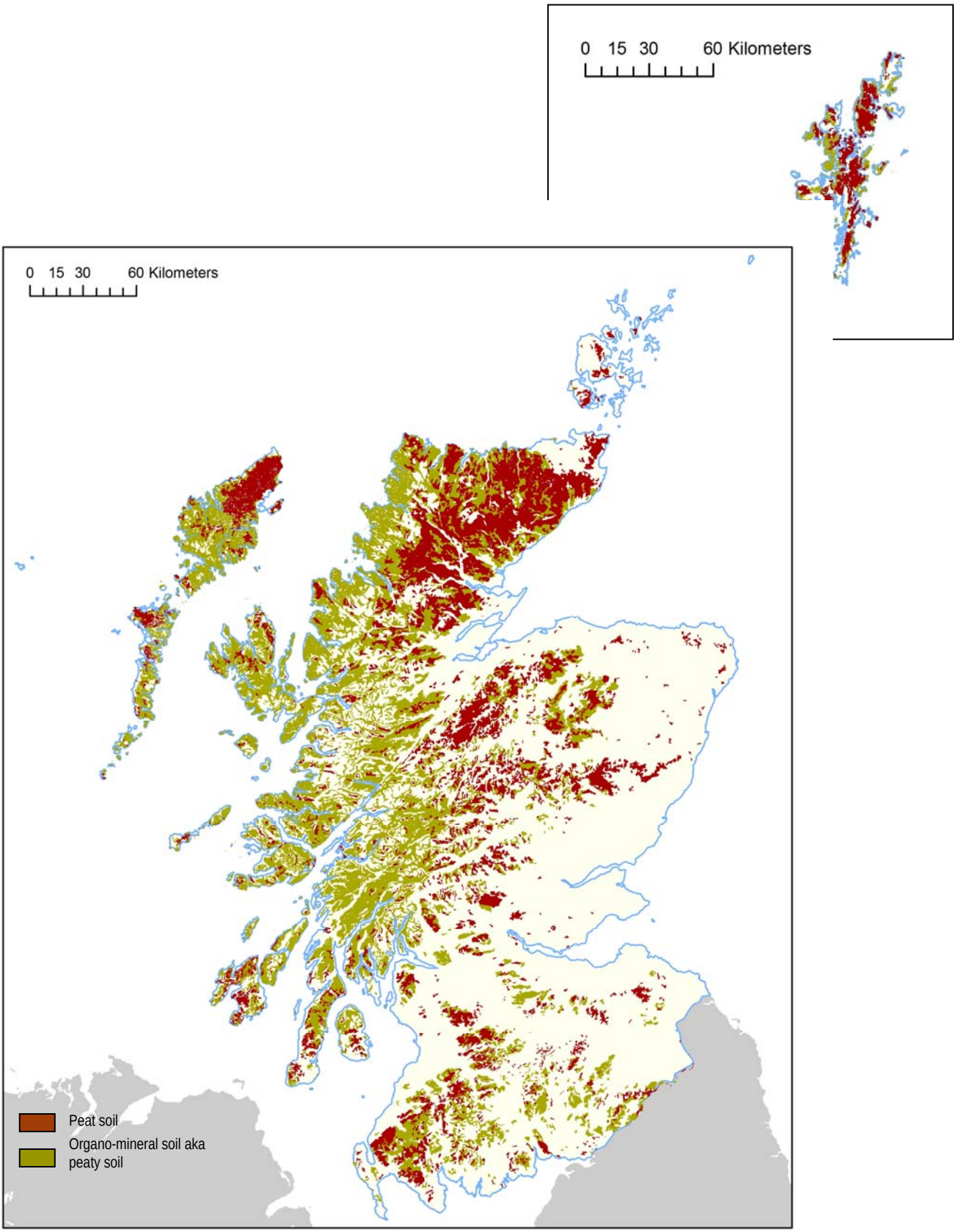


Figure 10. Location and extent of peat and peaty soils in Scotland, as identified from the Scottish Soils Map (*Reproduced by permission of Ordnance Survey on behalf of HMSO © Crown copyright and database right 2010. MLURI 100019294'*)

Table 19. Extent of peat map units in Scotland based on the Soils Map of Scotland (MLURI).

Mapping Units	Area (ha)	% Scotland (% UK)
Peat units		
Basin Peat	67,300	0.9 (0.3)
Eroded Basin Peat	800	0.0 (0.0)
Blanket Peat	371,100	4.7 (1.5)
Deep Blanket Peat	167,900	2.1 (0.7)
Eroded Deep Blanket Peat	30,900	0.4 (0.1)
Eroded Blanket Peat	125,900	1.6 (0.5)
Peat within other map units		0.0 (0.)
▪ Basin Peat	5,400	0.1(0.0)
▪ Semi-confined Peat	542,300	6.9 (2.2)
▪ Blanket Peat	415,500	5.3 (1.7)
Organo-mineral units	3,461,200	43.0 (14.0)
TOTAL	5,188,100	64.9 (21.1)

10.2 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 11).

The state of semi-natural peatlands in Scotland has been reported upon recently under the BARS process (Biodiversity Action Reporting System). Estimates on the extent and trends of peatland Priority Habitats for Scotland from the UK BAP reporting are given in Table 20.

Table 20. Extent and trends of the main peat forming vegetation Priority Habitats in Scotland.

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

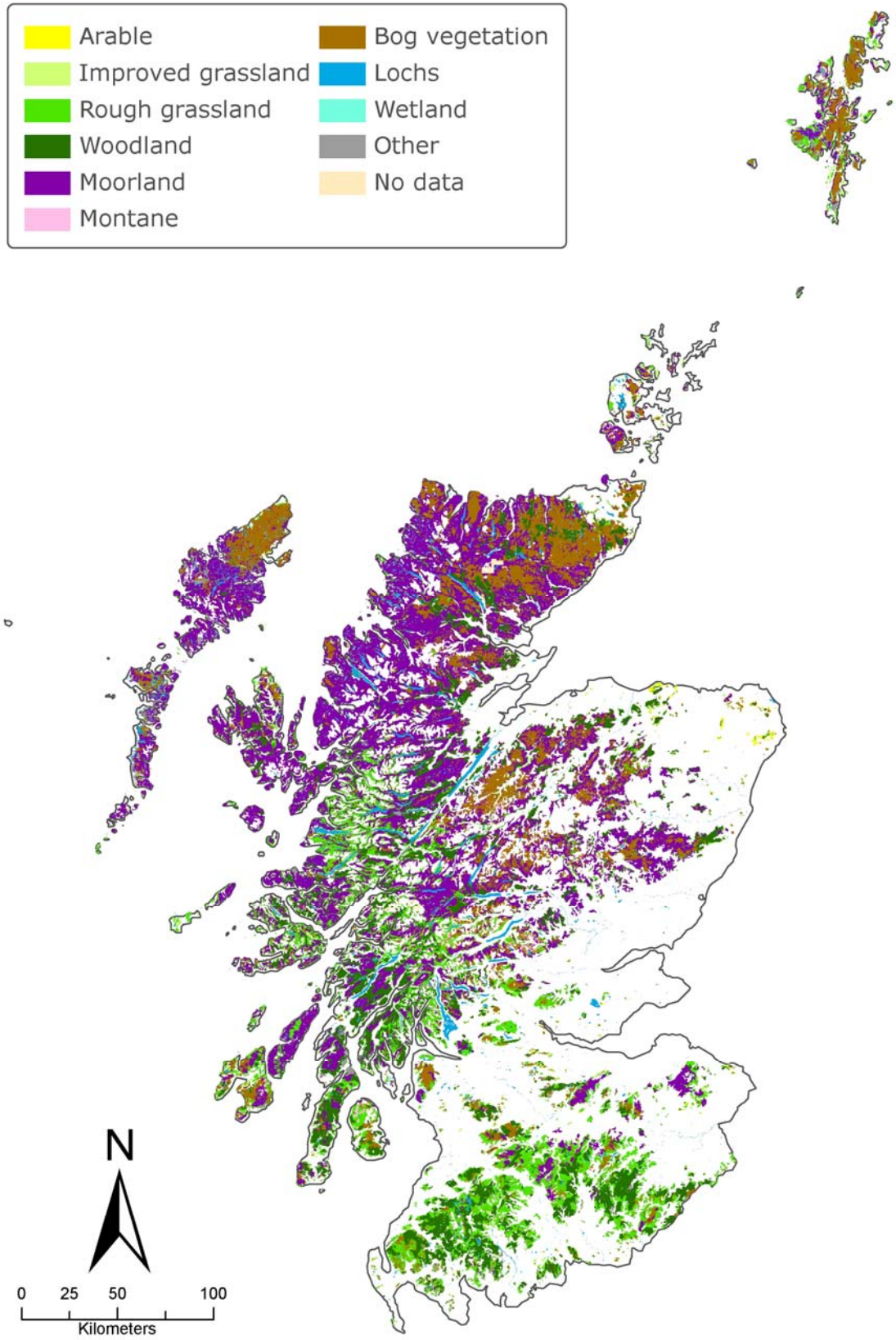


Figure 11. Land cover Scotland 1988 (LCS88) on organic and organo-mineral soils (*Reproduced by permission of Ordnance Survey on behalf of HMSO © Crown copyright and database right 2010. MLURI 100019294'.*)

Table 21 presents results from the Countryside Survey 2007 data that has been used to infer change in peatlands. The Broad Habitat 'Bog' in Scotland represents over 85% of the known extent of this habitat in the UK. No significant change was detected in Scotland between 1998 and 2007, but a significant decrease of 2.5% was observed for the Lowlands Environmental Zone (EZ4). 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 of this habitat. 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 21. 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	

The condition of natural features on designated sites is monitored through Scottish Natural Heritage's Site Condition Monitoring (SCM). Condition assessment of peat forming habitats within designated sites in Scotland has indicated that the favourable condition (and unfavourable recovering condition) proportion for blanket bogs is 61.7% (9.6%); upland fens, flushes and swamps is 61.2% (13.4%) and lowland raised bogs is 57.7% (18%) (SNH 2010.)

In terms of differences between the regions of Scotland, the features in the Central Belt lowland raised bogs were generally in better condition than other areas. This reflected the fact that, compared with other areas of Scotland, designated sites in the Central Belt were chosen from a much larger sample of raised bogs.

There were also significant differences in the percentage of sites in favourable condition between the different areas of Scotland for lowland fens, marsh and swamp. Those sites located in northern Scotland had 80% of features in favourable condition. East and west Scotland were both below the overall average, with 59% of features in favourable condition.

The number of blanket bog features in favourable condition differed across Scotland. The blanket bogs habitats in the west of Scotland were assessed to be in better condition than the those located in the North, and the ones in the east were below the overall average.

11 Discussion and conclusions

This report is the first time that such a range of peatland information has been brought together and it is hoped that an understanding of the differences in the data available will help address how the information is used. Peatlands are defined as "ecosystems with a peat deposit that may currently support a type of vegetation that is peat-forming, may not, or may lack vegetation entirely". Because of this dual vegetation / soil perspective, the description and characterisation of peatlands is dependent on 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 on UK peatland 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 peat soils and peatland. This now creates difficulties in having a common understanding and language on information about the state of peatlands. For example, the concept of shallow peat is applied differently between England & Wales and Northern Ireland, and is not formally recognised in the soil classification for Scotland (see Figure 1).

Differences in vegetation descriptions also complicate assessments of peatlands in the UK. Values reported for the extent of Broad and Priority Habitats are highly dependent on survey methodology. Vegetation definition, methodology, and scale of reporting can also contribute to the differences for each country and are detailed in sections 7 to 10. For example, the reported extent of the UK BAP Priority Habitat blanket bog in England is over 2,500km^2, but CS2007 only reported 1,400km^2 in the bog Broad Habitat category and the Natural England estimate extent of Bog Priority Habitats is 3,500km^2.

The data in Table 22 shows the relative cover of shallow peaty and deep peat soils across the four countries of the UK based on soil mapping and Priority Habitat cover data. The geographical differences are clear, and in most cases the data indicate significant areas of peat lacking a typical mire vegetation cover. It is not possible to draw direct comparison between those data as they reflect different methodologies for acquisition and definition. However, it suggests that at a country level the bogs and fens UKBAP habitats type are relatively more extensive in England as a proportion of the shallow or deep peaty soils in that country compared to the rest of the UK.

Table 22. Summary of organic-rich soils extent (in ha) and bogs and fen UK BAP type extent (in ha).

	Soil map data (see Tables 7, 12, 16, 19)		UK BAP data (see Tables 10, 14, 17, 20)	
	Shallow peaty or Organo-mineral	Deep peaty or organic soil	bogs	fens
England	738,618	679,926	272,719	8,000
Wales	359,200	70,600	71,830	6,200
Northern Ireland	141,700	206,400	160,902	3,000
Scotland	3,461,200	2,326,900	1,772,000	8,585

There is limited information on state and trends as few surveillance programmes and monitoring schemes operate at a consistent UK level. Available data often only considers limited aspects of peatland ecosystems in isolation (e.g. National Soil Inventory, Broad Habitats survey) or focuses on specific locations (e.g. international reporting obligations on protected sites). Such information is very useful within its context but has limited use in terms of providing a national assessment of peatland state and changes.

The following overall conclusions can be drawn from this report:

- 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.
- The information coverage and intensity of data recorded on peatlands significantly varies across the UK.
- Site specific studies and one-off surveys have indicated changes in the extent and quality of peatlands. By contrast, the changes in the wider extent and quality of peatlands have mainly been inferred from limited studies rather than extensive survey or statistically valid sampling.
- Information recorded on peatlands in the past was for specific purposes. We need better coordinated and consistent information gathering fit to allow new understanding on the function of peatlands. Policy objectives are needed that will ensure delivery of priority ecosystem services as it may not always be possible to maintain all ecosystem services in all peatlands, given costs, varying priorities of land owners, managers and members of the public, and the fact that some ecosystem services are mutually exclusive in the same location.(Reed *et al* 2010).

In part driven by the climate change mitigation agenda, extensive work is being undertaken at the UK level to overcome classification differences and monitor soils to improve our estimate of the soil carbon stock. Revision of estimates of the depth and location of peat soils will be a valuable contribution to any future review of the extent and status of peatlands. 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. The challenge for sustainable use of peatland is to work within the limits of the information available to draw new interpretation of evidence to address a range of new policy questions and emerging issues. This will secure sustainable management which delivers large-scale biodiversity and other ecosystem services in a manner which also delivers better resilience to climate change.

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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 Land Cover 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 2010) • 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

Data source	Description	Comments
Northern Ireland Peatland Survey (Cruickshank, 1988)	• Covers Northern Ireland's semi-natural peatlands • Mapped from management recorded • Identifies bare peat, heathland	• Does not cover peatlands under forestry or agriculture
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 o Scotland http://www.snh.gov.uk/protecting-scotlands-nature/protected-areas/site-condition-monitoring/ o England http://www.sssi.naturalengland.org.uk/Special/sssi/search.cfm o Wales http : //www.ccw.gov.uk/landscape-wildlife/protecting-our-landscape/special-landscapes-sites/protected-

Data source	Description	Comments
		landscapes/sssis/sssi-report.aspx ○ 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

Data source	Description	Comments
Agri-environment schemes	• Mapped areas of land managed under agri-environment agreements • Data collected since early 1990s. • Management options often apply to certain vegetation or land cover types • Scattered coverage • Data availability is restricted	• Can identify active bogs, fens, scrub, woodland, cropland, improved grassland and a range of semi-natural non-peat forming habitats
Regional and local wetland inventories	• Various sources in UK	

Glossary

This glossary is set out to provide definition to terminology used in this report.

Acrotelm	The surface layer of an active peat-forming mire, composed of the most recently deposited material, within which the water table fluctuates and where water moves more freely than in lower peat layers. See also **Catotelm**.
Active peat-forming	Describes peatlands subject to ongoing peat formation, often inferred from the presence of vegetation that is normally peat-forming. Often abbreviated to "Active". See also Habitats Directive definition of active in relation to Annex 1 habitats 'Active raised bogs' and 'Blanket bogs' contained in European Commission, 2003. Interpretation manual of European Union Habitats. Version EUR 25. EC DG XI, p82-83. (http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/2007_07_im.pdf).
Archaic peat	Term used in Lindsay and Immirzi (1996) to describe degraded peatlands with vegetation of agriculturally improved grassland or crops, or under built development.
Bare peat	Term used to describe areas of exposed peat.
Base-poor	Indicates low pH wetlands, deficient in base cations; pH range 4.5-5.5 (Wheeler *et al* 2009a).
Base-rich	Indicates high pH wetlands, rich in base cations and often bicarbonate; pH range 6.5 or above (Wheeler *et al* 2009a).
Bog	A mire which derives all its water supply from rain, snow or mist.
Blanket bog	Bog habitat which deposits expanses of peat that blanket the landscape. Includes both active and degraded versions of this habitat with semi-natural vegetation.
related definitions	- '**Blanket Bog'** UK Biodiversity Action Plan Priority Habitat (http://www.jncc.gov.uk/_ukbap/BAPHabitats03_Blanket%20Bog.doc). - '**Blanket bogs**' H7130 Priority Habitat - Habitat directive Annex 1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7130)**.**
Blanket peat	(aka) Blanket (bog) peat. Peat deposits formed by blanket bogs.
related definitions	- 'blanket bog peat' - BGS sub-category of peat deposits mapping - '**blanket bog peat**' - NSRI Soilscapes category.
Catotelm	The lower layer of an active peat-forming mire which remains permanently waterlogged, and through which water usually moves less freely. See also **Acrotelm.**
Condition assessment	A process for assessing the ecological condition of habitat features according to standardised criteria relating inter alia to species

	composition and structure (http://www.jncc.gov.uk/page-2217). The outcome of this assessment is used to assign features to a condition class.
Condition (of habitat)	The state of the feature at a particular point in time (each of which has subcategories relating to the change in condition since the previous assessment): a) favourable: maintained, recovered; b) unfavourable: recovering, no-change, declining; and c) destroyed: partially, completely.
Countryside Survey	The Countryside Survey is a stratified random monitoring scheme which provides a national network of sites across Great Britain, representing the main types of landscape, land cover and soil group. The Northern Ireland Countryside Survey uses similar methodology in Northern Ireland. These surveys have been repeated approximately every eight years since 1978.
Broad habitats	A system to describe groups of similar habitats, which is defined in, and used by the UK Biodiversity Action Plan, and also used for reporting land cover for countryside survey. The Countryside surveys report on two habitats relevant to peatlands, namely 'Fens, marsh and swamp' and 'Bog'.
Degraded habitat	Habitat which no longer supports its characteristic assemblage of species. Synonymous with unfavourable habitat condition See '**Condition**'.
Degraded peatland	Peatland supporting degraded habitat and/or peatlands and no longer active peat-forming.
Deep peaty soil	In England & Wales - A term used in the Partnership Peat Project mapping and England's Peatlands report (Natural England, 2010) to refer to areas assumed to have 40cm or more surface thickness of peaty material containing 20-25% or more organic matter by weight, or soils with 30cm or more such material resting directly on bedrock, or where deposits of 40cm or more such material are found buried under non-peaty deposits 30cm or less in thickness. In Scotland - This corresponds to peat soil mapping units characterised by the presence of surface peat layer containing more than 60% of organic matter and at least 50cm thick. In Northern Ireland - This applies to peat soil mapping units characterised by the presence of a surface peat layer containing more than 35% of organic matter and at least 50cm thick.
Diplotelmic	(of active peat-forming bogs) having a two-layered structure comprising an **acrotelm** and a **catotelm**.
Ecosystem services	A term used to describe the goods, benefits and costs to society delivered through the functioning of an ecosystem.

Eutrophic Nutrient-enriched (not necessarily also base-rich) (modified from Wetland Framework).

Fen Mire which receives water from surface runoff and/or groundwater in addition to direct atmospheric precipitation.

related definitions

- '**Lowland Fens'** - UK Biodiversity Action Plan Priority Habitat (http://www.jncc.gov.uk/_ukbap/BAPHabitats27_Lowland%20Fens.doc)

- '**Upland Flushes, Fens and Swamps'** - UK Biodiversity Action Plan Priority Habitat *(http://www.jncc.gov.uk/_ukbap/BAPHabitats59_Upland%20Flushes,%20Fens%20and%20Swamps.doc)*

- '**Transition mires and quaking bogs'** H7140 Habitats- Habitat directive Annex 1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7140)

- '**Alkaline fens'** H7230 Habitats- Habitat directive Annex 1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7230)

- '**Calcareous fens with Cladium mariscus and species of the Caricion davallianae'** H7210 - Habitats Directive Annex 1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7210)

- **'Depressions on peat substrates of the *Rhynchosporion*'** H7150 Habitats- Habitat directive Annex 1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7150)

- **'Petrifying springs with tufa formation (*Cratoneurion*)'** H7220 Habitats- Habitat directive Annex 1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7220)

- **'Alpine pioneer formations of the *Caricion bicoloris-atrofuscae*'** H7240 Habitats- Habitat directive Annex 1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7240)

Fen peat Peat deposited by fen habitats.

related definitions

- '**fen peat'** - British Geological Survey sub-category of peat deposit mapping.

- '**fen peat'** - NSRI Soilscapes category.

Mesotrophic With an intermediate input of nutrients.

Mineral soil Soil type mapping unit characterised by the presence of a surface layer containing less than 20% of organic matter (Scotland and Northern Ireland), less than 20-25% of organic matter (England & Wales).

Minerotrophic	Where nutrient supply is derived from mineral groundwater.
Mire	A wetland that supports peat-forming vegetation. Some authors use this term to include wetlands on mineral soils. See also '**Bog**' and **Fen**'.
Moorland	A term use to describe unenclosed upland areas dominated by a range of semi-natural vegetation. Not synonymous with peatlands.
Muirburn	A term used to describe rotational burning in Scotland.
Organo-mineral soil	In Northern Ireland defined as having more than 20% of organic matter up to 50cm deep; and in Scotland as having more than 20% of organic matter and more than 10cm but less than 50cm deep, or more than 10cm of surface horizon with 30-60% organic matter. For England and Wales see Shallow Peaty Soil.
Oligotrophic	Low fertility, nutrient poor (not necessarily also base-poor) (from Wetland Framework, Wheeler *et al* 2009b).
Ombrogenous	Deriving all its water supply from precipitation. See '**Bog**'.
Ombrotrophic	Where nutrient supply is derived from precipitation (rain, snow or mist), also referred to as rain-fed.
Peat	Partially decomposed remains of plants and soil organisms which have accumulated, usually in waterlogged conditions, at the surface of the soil profile or as material infilling water bodies.
Peat soil	In the UK soil classification system, describe a type of soil which includes all organic-rich soils. (See deep peaty soil, shallow peaty soil).
related definitions	- '**Peat deposits'** - a British Geological Survey class of organic deposit only including peat deposit extending deeper than1 metre below the ground surface. - '**Basin peat**' - a British Geological Survey sub-category of peat deposit mapping. - '**Hill peat**' - a British Geological Survey sub-category of peat deposit mapping. - '**Peat flow'** - a British Geological Survey sub-category of peat deposit mapping.
Peat-forming vegetation	Vegetation composed of species that are tolerant of waterlogged conditions and, as a result of these conditions, can form deposits of deep peat and thus sequestering carbon.
Peatlands	Land 'with a peat deposit that may currently support a vegetation that is peat-forming, may not, or may lack vegetation entirely.' (modified from Ramsar Convention 1971).
Rain-fed	See **ombrotrophic**.

Raised bog	Bog habitat which is characterised by an accumulation of peat that rises above the surrounding landscape often in lowland wet floodplains and/or often over surface of existing fen peat. Includes both active and degraded versions of this habitat with semi-natural vegetation.
related definitions	- '**Lowland Raised Bog**' UK Biodiversity Action Plan Priority Habitat (http://www.jncc.gov.uk/_ukbap/BAPHabitats31_Lowland%20Raised%20Bog.doc) - '**Active raised bogs**' H7110 Priority Habitat -Habitat directive Annex1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7110) - '**Degraded raised bogs still capable of natural regeneration**' H7120 - Habitat directive Annex 1 (http://www.jncc.gov.uk/Publications/JNCC312/habitat.asp?FeatureIntCode=H7120)
Raised bog peat	Peat deposited by raised bog habitats.
related definitions	- '**raised bog peat'** - a British Geological Survey sub-category of peat deposits mapping. - '**raised bog peat'** NSRI Soilscapes mapping category.
Shallow peaty soil	In England and Wales - Soil type characterised by the presence of a surface peat layer containing more than 20-25% of organic matter and at least 10cm and no more than 40cm thick . Term is not in use in Scotland or Northern Ireland but similar to Scottish Organo-mineral soil type.
Soil Organic Matter	Soil organic matter (SOM) refers to all organic material present in the soil including the remains of plants and animals at varying stages of decomposition and the living plant and animal material on and below the soil surface.
Soil Organic Carbon	Soil organic carbon (SOC) refers to the amount of carbon stored in the soil. It is often expressed as a percentage by weight or as g C/kg soil. SOC can be expressed into SOM though simple multiplication factor, usually taken as equal to 1.72 in mineral soils and closer to 1.92 in organic soils.
Soil profile	Vertical arrangement of soil layers forming the basis of all UK soil classification system.
Soil series	Group of soil profiles developed under similar conditions and similar parental material in UK soil classification. Also the smallest unit of soil mapping.
Soil association	A characteristic grouping of soil series, used to map larger areas, and normally bearing the name of the dominant series.
Waterlogging	Permanent or temporary saturation of the soil 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.