Natural England Board

Meeting: 16
Date: 20 May 2009

Paper No: **NEB PU16 07**

Title: **Natural England's Draft Policy on Soil**

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1. Purpose

1.1 This paper presents our draft Policy on Soil

1.2 Its development has included:

- submission of Natural England's response to Defra consultations on the proposed EU Soil Framework Directive, the draft Defra Soil Strategy and the draft Defra Code for the Sustainable Use and Management of Soil on Construction sites

- consideration by Board Outcome Groups 1 and 3

1.3 Soil, one of the key life support systems, is at the heart of what Natural England does and is fundamental to understanding the true benefits of the natural environment. Our soil activity is cross cutting and relevant to all our strategic outcomes and yet understanding and awareness of the importance of soil is low across both society and Natural England. This policy is designed to set the strategic context for our engagement and a framework for more detailed guidance to staff – the unusually long sections in Annex 1 on context, issues and evidence reflect our intent to improve understanding of this important subject.

2. Recommendation

2.1 It is recommended that the Board considers and approves the draft Policy for formal consultation with external stakeholders.

3. Overview

3.1 Soil is the living outer layer of our planet which provides a medium in which plants grow and a habitat where animals and other micro-organisms live. It forms a main component of the terrestrial ecosystems upon which our well being and prosperity is based. Soils are used for the production of food, timber and fibre, which are all essential for human existence. They are also a source of raw materials such as sand and peat and provide a platform for the built environment. Soil influences the pattern of land use and settlement and the local character of our landscapes, and preserves archaeological remains and other aspects of our cultural, natural and geodiversity heritage. (See Fig 1).

3.2 Soil provides a vital interface between the aquatic and atmospheric environments and their interlinked processes of biogeochemical and water cycling, flood control, gaseous exchange and carbon storage, both locally and on a global scale. Soil provides a vital range of functions (ecosystem services) for mankind which are essential to sustainable development. Soil is a finite resource which takes many years to develop but which can be quickly lost or degraded, in Roosevelt's famous words 'a nation who destroys its soil destroys itself'.

3.3 There are many pressures on our soils, especially erosion, compaction and organic matter decline and the impacts of development such as sealing and increased runoff and pollution. With climate change these pressures on our soils are likely to be exacerbated.

3.4 Following concern about the state of soils across Europe, the European Commission adopted a Thematic Strategy for Soil Protection in September 2006, which included proposals for a Soil Framework Directive. The proposed directive seeks to address seven key threats to European soils: erosion; organic matter decline; compaction; salinisation; landslides; contamination and soil sealing (covering the soil with an impermeable material such as tarmac or concrete) (See Figs 2, 3 and 4). Discussions on its potential content have raised the profile of soils up the environmental agenda though, at the time of writing, it is not clear whether the directive will be implemented.

3.5 Defra are shortly to publish a Soil Strategy for England, a successor to the First Soil Action Plan for England: 2004-2006. The strategy puts into an English context many of the threats identified in the Thematic Strategy and in the draft directive.

3.6 An understanding of soil is fundamental to developing an ecosystem approach to the understanding, conservation, planning and management of the natural environment. With its wide remit for the natural environment Natural England is in a strong position to be a leading advocate for soil conservation and sustainable use.

4. Summary

Natural England believes that:

4.1 Soil should be valued as a finite multi-functional resource which underpins our well being and prosperity. Decisions about the natural environment should take full account of the impact on soils, their intrinsic character and the sustainability of the many ecosystem services they deliver.

4.2 Soil is a key component of most landscapes and a significant component in understanding the links between landscape and the historic environment.

4.3 The role of soil in maintaining carbon stores and regulating greenhouse gases needs to be better appreciated, understood and embedded in habitat and land management practices in order that its potential to mitigate against the effects of climate change is realised.

4.4 Links between soil biota and their ecology and the capacity of soil to deliver vital ecosystem services, including biodiversity, are critical; more research is needed to inform better ecological management of soil.

4.5 Good soil management is a critical component of more sustainable land management practice – not only in agriculture, but also in forestry, woodland and recreational management, in construction, mineral working and restoration, waste disposal, in habitat restoration and re-creation and in urban design, green infrastructure and the creation of other greenspace.

4.6 When considering land use change we need to consider the permanency of the impact on soils and take particular care over planned changes to the most potentially productive soil (for the ecosystem services it supports and for its role in agriculture and food production) but we must also allow for necessary change, including for example the creation of habitats and coastal change in response to climate change.

Annex 1: Draft Policy on Soil

1 Context

Soil is the thin living upper layer of our Earth's crust comprising both topsoil and subsoil layers, which are composed of mineral particles derived from underlying geological materials, organic matter, water, air and organisms, and in which soil forming processes have transformed the parent material. English soils typically vary from a few centimetres to a metre or more in depth, and although they are young in a global context they represent about 10,000 years of ecological processes and human modification that has occurred since the last Ice Age. Soil is a finite natural resource which takes many years to develop but which can be quickly lost or degraded. Globally it is estimated that some 23% of the useable land area is already degraded.

England's soils are diverse, reflecting the wide range of underlying rock types, current and past vegetation and drainage, and are variable in their characteristics. Soil types can change from field to field because of complex interactions between underlying geology, landform, past and existing land use and climate. The geological parent material determines the physical and chemical nature of the soil; the wide diversity of types encompasses shallow calcareous soils over chalk and limestone, acid well drained soils derived from sandstone and sands and gravels, to poorly drained soils often associated with clays, mudstones and shales, as illustrated in Fig 1.

In turn this has a fundamental influence on the distribution of habitats, species and landscapes and the changing patterns of land use that have been superimposed on them throughout human history as people have farmed the land and harnessed its resources.

The term soil can include a wide range of substrates such as sand dunes, riverine or estuarine sediment at one extreme and deep upland peaty soils at the other. The breadth is complex but conventionally only those low lying sediments which lie beyond the reach of daily tides, are ripened (the transformation of soft anaerobic sediment into aerated soil structure) and usually vegetated are considered as soil. Other sediments are not covered by this policy.

Soil is a medium in which plants grow and a habitat where animals and other micro-organisms live. It forms a main component of the terrestrial ecosystems upon which our well being and prosperity is based. Soils are used by farmers for the production of food, timber and fibre, which are all essential for human existence. They are also a source of raw materials such as sand and peat and provide a platform for the built environment. Soil also influences the pattern of land use and settlement and the local character of our landscapes, and preserves pollen, archaeological remains and other aspects of our cultural and geodiversity heritage.

Soil plays a key role in sustaining a healthy natural environment, for example through pollution prevention, by breaking down or reducing the impact of chemical contaminants or by storing and releasing water. However, it can also represent a source of excessive water run-off, sediment, nutrients and other pollutants if mismanaged which can have serious impacts on freshwater ecosystems. Soils are an integral component of the global carbon cycle, storing more carbon than in the vegetation and atmosphere, and so vital to global climate regulation. When degraded soils can become major sources of greenhouse gas emissions if the carbon stored is lost.

As soil performs so many vital functions (ecosystem services) for mankind, its wise use and management is essential to the delivery of sustainable multi-functional land use and the protection of the natural environment. This presents many challenges in reconciling the competing demands that society places on our land and soils.

An understanding of the links between land use and agricultural practices, and good soil management and soil carbon storage, will be a crucial part of our strategies for ensuring the future of the natural environment, particularly tackling the challenges of climate change, and delivering sustainable agriculture and food security. These links are also important to develop the way people understand and value what soil does for us and inspire them to appreciate and conserve geodiversity and the wider natural environment.

Understanding soil characteristics and processes is key to identifying appropriate locations for habitat restoration and re-creation schemes and for achieving conservation, recreation and access objectives at a wider scale in the landscape.

Increasingly we know more about soil ecology and understand how this complex living system drives the essential soil forming, carbon and nutrient cycling processes. However, there is a great deal more to learn. Although there is increasing evidence that plant-microbial associations are extremely important in maintaining healthy plant communities and have a major influence on plant diversity, more evidence is urgently needed. Soil biological communities are very susceptible to disturbance especially those caused by human intervention, but the full implications of this disturbance are currently only partly understood. In England there are few soils which have not been modified by human intervention; those which are less modified can have an intrinsic, scientific and educational value in the same way as the long established habitats with which they are normally associated.

There are many pressures on our soils resulting from the way they are used and managed, particularly by intensive agricultural production, (including increased run-off, accelerated erosion, compaction and organic matter decline) and the impacts of development such as sealing and increased run-off and pollution (see Fig 2 for example) . With climate change many of these pressures on our soils are likely to be exacerbated, as hotter drier summers may lead to lower soil moisture levels and wetter warmer winters may increase the risk of soil structural damage and poorer water infiltration, giving rise to erosion, waterlogging, flooding and diffuse pollution.

Soil, particularly peat and other highly organic soil, is a major store of carbon in the form of soil organic matter. When in pristine condition, peat bogs are able to accumulate carbon but draining, and cultivation or extraction of peat as a growing medium for the horticultural industry means that they become a source of carbon as well as damaging their biodiversity, archaeology and water storage functions. For mineral soils, loss of organic matter is also detrimental to the quality of the soil as it is important for fertility, stability and water retention, and a key indicator of soil health. Loss of carbon from soils to the atmosphere is likely to reduce the effectiveness of the UK programme to reduce carbon emissions and exacerbate other soil problems such as compaction and capping which lead to run-off.

Inappropriate land management can impact on soil, affecting its status as habitat and limiting its agricultural capacity as well as other aspects of functionality. Poor structural condition, such as compaction, reduces water infiltration, which limits aquifer and river recharge and causes surface water run-off and erosion problems. This has adverse effects on the wider environment such as receiving watercourses or ponds, and increases clean up costs after floods.

Development of buildings and infrastructure prevents alternative uses for those soils that are permanently covered, and also often results in degradation of soils around the development as result of construction activities. This affects their functionality for food production, as wildlife habitat, and reduces their ability to support landscape works and green infrastructure. Sealing and compaction can also contribute to increased surface run-off, ponding of water and localised erosion, flooding and pollution. Land restoration following mineral working and waste disposal activities may result in soil being reinstated, but the replaced soil is often degraded, and in some cases lost as a component of the workable resource, or contaminated, by poor working and restoration techniques. Land restoration can, however, offer opportunities for habitat creation, particularly on lower quality agricultural land.

Soil contaminants include metals, hydrocarbons and other organic pollutants, pathogens and substances that can acidify or enrich soil with nutrients. Locally, contamination can arise from active mining and industrial processes and accidental spills. More widespread pollution arises from aerial deposition, agricultural uses of land, and run-off from roads, urban areas, industrial and construction sites.

Despite the threats, little statutory protection exists specifically for soil either within the EU or UK, although it is indirectly protected by other legislation, such as that for the prevention of pollution and contamination, and for planning. As these measures have other aims and scopes of action, they are not always sufficient to ensure an adequate level of protection and soil tends to be dealt with in an uncoordinated and piecemeal way, and consequently not valued as a natural resource in its own right. Even the NERC Act 2006, that established Natural England, refers to soils only indirectly.

In response to this historical neglect of soils, the European Commission adopted a Soil Thematic Strategy (COM(2006) 231) in September 2006, and proposed a Soil Framework Directive (COM(2006) 232), with the objective of protecting soils across the EU. The strategy and the proposed directive have been important in raising the profile of soil. At the time of writing, although the strategy has been endorsed, it is not clear whether the directive will, in fact, be implemented.

The proposed directive primarily seeks to address seven key threats to European soils: erosion, organic matter decline, compaction, salinisation, landslides, contamination, and soil sealing.

Defra are shortly to publish a Soil Strategy for England, a successor to the First Soil Action Plan for England 2004-2006, which addresses many of the threats identified in the Thematic Strategy and the draft directive within an English context. The proposed Defra strategy has an overarching vision that '*England's soils are protected and enhanced to optimise the benefits they provide for this and future generations.'*
Five key priority areas lie at the heart of the strategy:

- Climate change and soils – mitigation and adaptation
- Addressing soil degradation in the agriculture and land management sectors
- Preventing pollution of rural land: recycling materials to land and atmospheric deposition
- Ensuring soil protection in construction and development
- Contaminated Land

2 Issues

Soil is now gaining attention as global environmental issues such as climate change, desertification, changing land management practices and food security come to the fore. As soil receives greater recognition, the conflicting views that can arise about how best to optimise the various functions provided, present challenges in reconciling the competing demands that we have. A key issue for Natural England is to recognise these views without over simplifying them and to develop sustainable solutions.

However, there remains a low level of awareness and understanding of the issues that affect soil. In this country policy and decision makers often take less account of the impact of policies and actions on soils than they do for other components of the natural environment such as air and water. The complex multifunctional role of soil is often overlooked or taken for granted.

Improving awareness of soil is key as the quality and management of soils do not generate the same level of public debate as other aspects of the environment. It is not often appreciated that soils are important habitats in their own right. Similarly, soils are not always properly accounted for in land use planning. In part this is due to a lack of recognition of the importance of soil and the benefits provided, but also due to a lack of clarity in the responsibilities of the various delivery bodies.

Information on soil is not widely available, is often difficult to interpret by the non expert and mapped information may not be available at scales suitable to address local issues. This further hinders a better understanding which is important if soils are to receive the attention they require. More emphasis should be given to exploring and demonstrating the links between soils and landscape (including geodiversity), biodiversity, food quality, and climate change, and the fundamental role played by the soil biological and physical processes which underpin them. Character Areas, for example, can help to address this by providing a framework that already reflects the broad diversity of soil types, which can be used to inform landscape management, land use strategies and conservation policies.

Over the course of this century, it is predicted that a combination of climate change and intensified land use will weaken the ability of soil to sequester and store carbon. Halting the loss of soil carbon is important because this is both detrimental to soil functions as well as contributing to greenhouse gas emissions. Climate change is also likely to directly affect soil processes and future capabilities and so soil needs to be resilient. In particular, peat soils are a major store of carbon and action to protect them has been identified as a priority by Defra, Natural England and other UK partners.

The conservation of soil biodiversity and soil ecosystems has been neglected. Conservation strategies based on soil systems or species or the intrinsic value of rare soil types are in an early stage of development, but could be considered alongside the long established habitats with which they are normally associated. The development of this also requires consideration of an ecosystems approach, and more evidence is needed to explore this further. However, it is recognised that the link between soil ecology and the functional aspects of soil is key to understanding the delivery of a range of ecosystem services. There is increasing evidence that plant - microbial associations are critical drivers of plant diversity: this evidence could help us meet our above ground biodiversity targets and could also help develop understanding of the wider soil requirements for successful habitat creation and management, important for the success of climate change adaptation strategies.

Inappropriate land management can impact on soil, potentially limiting functionality and sustainable use. This is reasonably well understood for agricultural soils but is only now being addressed for those soils in other uses, including forestry and woodland, in the urban environment or where construction activities are taking place. Good soil management is equally applicable to all land uses to ensure the protection of the soil resource and to optimise the ecosystem services delivered and is also important for the long term success of habitat creation, outdoor recreation and amenity projects.

However, good management for one use, such as intensive agricultural production (e.g. maintenance of drainage, use of fertilisers) may be counter for what is required to conserve biodiversity and maintain landscape character. The key is to enable both improving and restoring the quality of soil, to support agricultural productivity, environmental protection and biodiversity.

Some soil functions can work together so that benefits arising from a particular soil protection measure may extend beyond the original aim e.g. the conservation of peatlands for their biodiversity and carbon storage will also help protect their value for archaeology and the wider historic environment. However, different soil functions are not always mutually compatible; for example an enhanced biodiversity function (e.g. new wetland) provided by coastal realignment, or in functioning as a platform for development involving soil sealing, may not be compatible with a soil’s food provisioning role.

These land use conflicts and their impacts on soil need to be acknowledged and worked through. When considering land use change we need to consider the permanency of the impact on soil. As Government planning policy seeks to protect the potential of our most highly productive agricultural soils from permanent (irreversible) loss, this is also an important consideration when land use change is proposed. Following the NERC Act (2006), Natural England became a statutory consultee for statutory planning consultations for minerals and waste proposals, including specific responsibility for the protection of high quality agricultural land, afteruse and aftercare.

3 Policies

1. Soil should be valued as a finite multi-functional resource which underpins our well being and prosperity. Decisions about the natural environment should take full account of the potential impact on soils, their intrinsic character and the sustainability of the many ecosystem services they deliver.

Soil is an integral part of our geodiversity and biodiversity and is one of the essentials of life, along with air and water, but because it is not perceived as a public good in the same way as air and water are, there is a danger of taking it for granted. Protection and sustainable management needs to recognise and optimise the many different functions that soil performs in keeping with the principles of sustainable management and development.

Soil is a finite natural resource which takes many years to develop but which can be quickly lost or degraded. Globally it is estimated that some 23% of the useable land area is already degraded. In England there are few soils which have not been modified by human intervention; those which are relatively undisturbed and exhibit features responding to natural processes and function can have an important intrinsic, scientific and educational value.

Increasing the awareness of soil at all levels is vital as policy and decision makers do not always recognise the importance of soil or value it as an important natural resource to be viewed with a long term perspective, and protected in the same way as other components of the natural environment. Land use planning, in particular, should play a key role in protecting soil and its functions, not just the agricultural functions but also those associated with carbon storage, habitats, landscapes and the historic environment.

Similarly, there is a widespread low level of public awareness and understanding of the issues and the links to other aspects of the natural environment or to global threats such as climate change. Farmers and other land managers may not appreciate their role as soil managers and the impacts that their actions can have on the long term functioning of soil.

<u>Evidence</u>

It is generally recognised, for example by the 1996 Royal Commission on Environmental Pollution report on the 'Sustainable Use of Soil', that soil protection has received less attention than the protection of air and water. This was officially acknowledged in May 1999 when the Government published 'A Better quality of life: A strategy for the sustainable development in the UK', and was followed by the First Soil Action Plan for England: 2004-2006 produced by Defra. This Soil Action Plan was the first to acknowledge and promote the multi-functional nature of soil, an approach to be continued in the Soil Strategy.

Soils are often resilient to pollution or poor management, so degradation of condition and quality may not be immediately recognised, unless highlighted by damage to other aspects of the natural environment. Loss of soil through development or other changes in land use is rarely recognised and the quality of soil resources is often overlooked in the creation of successful greenspace or in habitat recreation projects. Lack of reference to soil in spatial planning documents (for example The South East Plan) has been identified by Natural England in its planning work. Soil inputs are important for a thorough understanding of environmental capacity and the cumulative impacts of development.

2. Soil is a key component of most landscapes and a significant component in understanding the links between landscape and the historic environment.

An understanding of soils, their natural qualities and their role in supporting human survival, is essential to an understanding of landscape and links with the historic environment. Character Areas reflect the broad diversity of soil types, and can be used as a framework to inform landscape management, land use strategies and conservation policies, though detailed soil data may not always be at a suitable resolution for local decision making, or for interpretation by a non expert.

The way people have lived on the land and harnessed its soil resources over centuries can be seen from archaeological remains, changing forestry and agricultural land use, and from the pattern of quarries and industry, and settlements, towns and cities. A degraded soil results in a reduction of its ability to perform its vital functions and in turn a despoiled landscape and loss of aesthetic appeal and cultural heritage.

An important function of soil is to store elements of our geological and archaeological heritage, by holding important clues for interpreting the past such as features of the soil themselves such as the structure or distinctive horizons (layers) or pollen records, or layers, artefacts or other remains related to human use of the environment.

Evidence
For mineral soils, the source rock or sediment typically determines the physical and chemical nature of the soil. Chalks and limestones lead to an alkaline usually well drained soil; sandstones, sands and gravels typically form acidic well drained soils; whilst finely grained rocks such as clays, mudstones and shales often form poorly drained soil. The action of vegetation and soil fauna, influenced by climate and relief turn this raw material into a variety of soil types. For example where the growth of vegetation is faster than the decay of organic matter by soil organisms, thick peat deposits can build up.

Our civilisation has exploited this natural variation in landforms and their associated soils and the different vegetation suited to them to develop the character of our current landscapes. Fertile well drained lowland soils have been prioritised by farmers for arable and root crops and particularly in the past, were the focus for settlement, whilst wetter soils have provided pasture for meat and dairy production. Poorer, thinner or more marginal soils are often managed as woodland for timber or used less intensively for agriculture giving rise to many of our semi-natural habitats.

The development of our civilisation and its interactions with the land are documented by artefacts and features preserved in the soil or as a feature of it. For example, there may charcoal layers or artefacts which can be dated, or that the soil records former climate and habitat conditions. Damage to the soil strata or removal of soil layers has the potential to destroy the context, or damage the archaeological material itself.

3. The role of soil in maintaining carbon stores and regulating greenhouse gases needs to be better appreciated, understood and embedded in habitat and land management practices in order that its potential to mitigate against the effects of climate change is realised.

Soil, particularly peat, is a major store of carbon in the form of soil organic matter. Any loss of carbon from soils to the atmosphere as CO_2 (as well as methane and nitrous oxide) contributes to UK greenhouse gas emissions and so could potentially have a major detrimental effect on our ability to meet greenhouse gas reduction targets. Government policy is to maintain levels of soil organic matter and where appropriate to increase levels.

A number of land management practices have the potential to increase carbon storage in mineral soils (such as reduced tillage, increasing organic returns, buffer strips, etc). The protection and restoration of peat and other highly organic soils is also important for maintaining soil carbon levels. Land management practices that can protect and enhance soil organic carbon should therefore be encouraged and where possible their contribution to climate change mitigation quantified.

It is important that farmers and other land managers are aware of and understand the direct and indirect impact of climate change on soils in order to ensure they are resilient in the face of change.

Evidence

Fig 3 illustrates the distribution of soil organic carbon at a European level. Ten billion tonnes of carbon are estimated to be stored in UK soils, with over half stored in peat. Indeed it is estimated that the soils of the English Uplands contain more carbon than all the trees in the UK and France added together. There is some evidence to suggest that levels of carbon are declining in some UK soil (see Fig 2b), although there is some uncertainty about these findings and some contradictory evidence. The trends are not clear cut and the discrepancies between these studies need to be resolved. Moreover, further losses of soil carbon could also occur as a result of climate change itself, due to changes in temperature and soil moisture which speed up the decomposition of organic matter.

There is evidence (from the UK and internationally) that degraded peat soils lose carbon at a significant rate. Much of this carbon loss is in the form of CO_2, as well as fluvial losses (which have implications for water quality). However, to date there has not been enough monitoring of carbon and GHG budgets in the uplands to estimate the overall scale of carbon loss. In the lowlands, there is stronger evidence of carbon losses from peat fenlands which where cultivated can degrade by as much as 1-2cm in depth of peat per year. A high proportion of these soils are cultivated and drained and, according to the UK Greenhouse Gas Inventory, emit 1.5 million tonnes of CO_2 a year but recent analysis by Natural England suggests that CO_2 emissions are more likely to be in the region of 3 MtCO, as the Inventory gives only a partial picture.

Peatland restoration (i.e. raising the water table back to near the surface of a peat bog or fen) will reduce CO_2 losses but may in some cases increase methane emissions. As methane is a more potent greenhouse gas than CO_2, it is possible that restoration may not always deliver a net greenhouse gas benefit. Improving our understanding of the greenhouse gas implications of peatland restoration is a major evidence need.

For mineral soil, recent research into the contribution that Environmental Stewardship makes to mitigation has been able to quantify the changes to average soil organic carbon from all ES options. This research concludes that ES reduces England's agricultural GHG emissions by around 11% a year (ie emissions would be 11% higher if there were no scheme in place). Much of this saving is in the form of increases in soil organic carbon delivered by options such as buffer strips. However, most mineral soils can only store a limited amount of carbon before they reach an 'equilibrium'. Furthermore, any additional carbon stored can be quickly lost if there is a change of management, such as cultivation.

4. Links between soil biota and their ecology and the capacity of soil to deliver vital ecosystem services, including biodiversity, are critical; more research is needed to inform better ecological management of soil.

Soils are important habitats/ecosystems in their own right and links between soil biota and ecology and the functional aspects of soil are key to a better understanding of the delivery of ecosystem services, and in developing our understanding, for example, of soil requirements for successful habitat maintenance and creation.

Soils are dynamic living interfaces that are habitats for millions of species, ranging from 'invisible' bacteria, fungi, microbes, microscopic invertebrates to larger invertebrates such as ants and earthworms. This species richness is mostly unknown, poorly understood and rarely considered in management decisions despite it being crucial to the wellbeing of all life, both below and above the surface. They drive the essential soil-forming, and regulating processes of the global carbon, nitrogen and phosphorous cycles as well as the more tangible functions of filtering water and producing food and timber.

It is highly probable that many habitats of nature conservation value are sustained and maintained by soil biodiversity. An increased understanding of how biodiversity relates to ecosystem functioning is required if we are to make informed choices and develop best practice guidance about land use and management, habitat management, restoration and re-creation. This could include exploring conservation strategies based soil systems or species or the intrinsic scientific and educational value of rare or relatively undisturbed soil types, recognising there could be conflicts with the delivery of other ecosystem services.

The proportion of soils which have not been modified by intensive farming techniques or human intervention is very small and consequently the prospects for the recreation of some habitats may be constrained. Our knowledge of the soil requirements for many habitats remains incomplete and effort is needed to address both a skills gap and the delivery of further research.

Evidence

Soil biodiversity is probably the largest component of total biodiversity. It has been estimated that only between 1 and 5% of all micro-organisms on Earth have been named and classified. A large proportion of these unknown species are thought to reside in the soil and it has been estimated that the microbial biomass from a hectare of arable soil has the same mass as 300 sheep.

Several research institutes and universities are studying soil biodiversity in the UK, including the NERC Thematic Programme on Soil Biodiversity which focussed on ecosystem function. Other recent research is showing, for example, that a key requirement for successful habitat restoration is the enhancement of efficient nutrient recycling in soil and the development of important plant-microbial associations which facilitate species diversity.

5. Good soil management is a critical component of more sustainable land management practices – not only in agriculture, but also in forestry, woodland and recreational management, in construction, mineral working and restoration, waste disposal, in habitat restoration and re-creation and in urban design, green infrastructure and the creation of other greenspace.

There are many threats to soils including accelerated soil erosion, compaction and loss of organic matter and loss of soil biodiversity which impact on their ability to perform vital ecosystem services such as the provision of clean water, acquifer recharge and flood control, regulating greenhouse gases, and the productive capacity of land. Climate change has the potential to magnify many of these threats as hotter drier summers may result in lower moisture levels and greater levels of wind erosion. Wetter warmer winters may increase soil moisture levels and the potential for poor soil structure such as compaction by heavy machinery. More extreme rainfall events means soils may become more vulnerable to water erosion with consequent risk of diffuse pollution and flooding.

With over 70% of our land area farmed nutrient and sediment losses from agriculture is a major source of water pollution, with phosphorous carried away on eroded soil particles, and nitrate by subsurface leaching. This is often caused by poor timing of applications in relation to the weather, or where applications exceed crop requirements.

The risk of soil degradation together with the ancillary pollution can be reduced by good soil management which will also help to ensure that soils are resilient in the face of climate change. It therefore important that opportunities are taken for soil to be embedded in the CAP reform agenda. Good soil management is crucial and needs to be delivered in all aspects of land management including in areas where this has not previously been a priority. This includes in the re-creation of habitats and in the urban environment where there are synergies with the development of successful recreational and amenity areas and other green spaces.

There may also be opportunities to improve and restore soil quality where needed, by promoting and applying existing soil and land management techniques (e.g. rotational farming), and to develop new approaches to management that combine support for the productive capacity of soil, ecological functioning and environmental protection.

<u>Evidence</u>
The loss of soil through accelerated erosion has received much attention due to its impact on water quality, habitats and archaeology, and through damage to properties and infrastructure due to the unwanted and or polluting deposition of sediment. However, it can also have a negative economic impact on farmers and other land mangers through crop or plant losses, loss of fertilisers and topsoil. As illustrated in Fig 4, typical water erosion rates are of the order of <1-20 tonnes/ha/yr, moving some 2.2 million tonnes of arable topsoil annually in England and Wales, but it is estimated that non water erosion processes (wind, tillage, soil loss due to crop harvest) may be equally as important as soil erosion caused by water.

Defra estimate that the annual total cost of the impact of soil erosion, including on site and off-site costs, due to agriculture to be £45 million. This figure will be an underestimate as it does not take into account the long term cumulative impact on soil functionality or the costs of restoring degraded habitats.

Soil organic matter is being lost through oxidation due to cultivation, erosion and land use change; climate change itself may lead to losses due to warmer temperatures. Evidence suggests that by improving the management of soil organic matter there are benefits for soil quality (improved stability, fertility and water retention), and the financial returns for farmers can be improved to the equivalent of £31 - £66 per hectare as a result of ease of tillage, fertiliser saving and higher yields.

Compaction is an issue for arable and grassland soils and for urban soils as a result of heavy construction machinery. Compaction decreases the water infiltration capacity of the soils, reduces aquifer recharge and increases the risk of run-off leading to flooding. It also increases the risk of erosion, adversely affects crops, landscaping or other vegetation, and has a negative impact on both above and below ground biodiversity. On construction sites poor soil management has been shown to unnecessarily increase the cost of development as well as resulting in poorer outcomes for the natural environment.

6. **When considering land use change we need to consider the permanency of the impact on soils and take particular care over planned changes to the most potentially productive soil (for the ecosystem services it supports and for its role in agriculture and food production) but we must also allow for necessary change, including for example the creation of habitats and coastal change in response to climate change.**

Soil sealing as a result of built development and construction activity has a major impact on soil reducing its capacity to fulfil many important functions. Depending upon its location, development, or other irreversible change in land use, will also reduce the nation's finite stock of high quality agricultural land. By protecting enough of these highly productive soils ('best and most versatile land' i.e. grades 1, 2 and 3a in the Agricultural Land Classification system which Government Planning policy seeks to protect as it contributes to both sustainable development and sustainable agriculture outcomes), which could be used for agriculture and food production if required, and valuing the other benefits provided (e.g. aquifer recharge, flood control) whilst allowing for other required land use changes (such as the creation of new habitats, coastal change and the development of the rural economy), will allow us to respond positively to the challenges of food security in the future This high quality resource is also that which is likely to be most flexible, productive and efficient in response to inputs and can therefore make a positive contribution to sustainable agriculture.

Evidence

There are increasing pressures on our land including population growth and the need for more housing, minerals, and infrastructure means an increasing demand for land for development (see Fig 2d), which is often on high quality agricultural land. In England between 2001 and 2003, around 5860 ha per year changed from previously undeveloped to developed land. Increasing demand for biofuels and food as well as the longer term risks relating to climate change, including sea level rise means that it is important to manage and monitor our most potentially productive land. Indeed, it is estimated that some 60% of our highest quality Grade 1 agricultural land lies below 5m AOD and is at risk of loss or degradation due to sea level rise, irrespective of other losses to development.

The cross Government Land Use Project aims to take a long term view of land use in England, looking ahead to 2050 and beyond. The project is underpinned by the concept of land as a finite resource which is under increasing pressure from a complex range of factors, including climate change and population growth. The consideration of soil issues is likely to be a significant factor in the project.