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# The state of soils in England and Wales

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The Environment Agency is the leading public body protecting and improving the environment in England and Wales. The Agency's strategy for soil explains some of the actions we are taking to help protect and improve soils. The main areas of our work relevant to soil are:

**Contaminated land**

We provide guidance on how to tackle land contamination and work with local authorities to identify and clean up contaminated land.

**Flooding**

We are the leading body responsible for flood risk management. In order to prevent development on flood plains, we tell the public and planning authorities which areas are at risk. We manage many flood defences.

**Water quality**

We regulate water abstractions and effluent discharges to water. We seek to improve surface and groundwaters by promoting land-use practices that prevent or minimise pollutants entering water.

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We regulate the handling, treatment and disposal of waste, including the recovery of waste and other materials to land. We promote waste minimisation by businesses.

**Land use**

We provide environmental advice, and work with others for the sustainable use and management of rural and urban land.

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Rio House
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# Foreword

Few consider the wide range of goods and services that soil provides: food, timber, wildlife habitats, clean water, flood control and a place to live. Neglect the soil and sooner or later the consequences will be evident – in loss of food production, polluted water supplies, flooding or declining wildlife. And once soils are seriously degraded they are almost impossible to restore to a healthy state.

Yet the growing signs of soil-related problems in England and Wales are testimony that soil has been taken too much for granted. There is a steady loss of soils to development, contaminated sites, damage by muddy floods and water pollution by silt and fertilisers. Such damage is costly and makes it increasingly difficult to meet environmental objectives for habitat protection and water quality. In the longer term, it threatens the conservation of soils for future generations.

Scientific understanding of soil is lacking in many areas. The diversity of life below ground far exceeds that above it and is vital to soil health and function, but these connections are only just beginning to be explored. While some of the impacts of mismanaging soil are obvious, dealing with them effectively requires a better knowledge of how soil, water and air interact. A growing scientific understanding must be translated into practical information and advice for land managers.

Those working in agriculture have a major responsibility and interest in looking after the soil. The latest reforms to the Common Agricultural Policy are welcome, but further change is needed to make agricultural use of soil more sustainable. At the same time urban soils must not be ignored. Planners and developers can help to protect soils and reduce flooding by working with the natural drainage function of soil. Industry too must prevent chemical spillages that pollute soils and groundwaters.

This report summarises current knowledge about the condition of soils. It highlights some of the major concerns that the Environment Agency wants to tackle in partnership with the many people and organisations that have a stake in protecting this vital resource. The Agency is committed to taking this forward in its own strategy for soil that will contribute to the programmes for soil being developed by the Department for Environment, Food and Rural Affairs and the National Assembly for Wales.

Paul Leinster    Director of Environment Protection

# Contents

# Summary

## The policy challenges

### Improving the knowledge base

The principal conclusion of this report is that there is not enough good quality information on the soils of England and Wales. Without this, it is not possible to develop effective policies and programmes to protect this fundamental resource. There is a need to improve the knowledge base and the access to practical information on soils and the pressures on them.

### Understanding soil biodiversity

The nature and role of soil biodiversity is vital to healthy soils and need to be much better understood. The gaps in knowledge include:

- standardised methods and benchmarks for soil biodiversity
- the effects on soil biodiversity of changes in the environment and farming practices
- the links between soil quality, soil biodiversity and above ground biodiversity.

This information should be turned into key indicators and practical advice for land managers and policy-makers.

### Integrated management of soil, water and air

- Soil, water and air are strongly interdependent and must be managed as part of one whole.
- Diffuse pollution of water from agricultural soils has to be reduced to achieve good water quality.
- More needs to be known about the interactions between climate change and soils, including the role of soil organic carbon as a source and sink of carbon dioxide.
- Further reductions in air pollution are needed to protect soils from acidification and nitrogen enrichment.

### Tackling the impacts of intensive agriculture

Intensive agriculture can be damaging to soils and water. More sustainable practices need to be promoted.

- To protect soils and reduce diffuse water pollution, further targeted measures are needed under the Common Agricultural Policy. These include advice and training to help farmers maintain the land in good agricultural and environmental condition.
- To prevent persistent chemicals or excess nutrients accumulating in soils, land managers must take all inputs from land spreading and other sources into account. Better information is needed on the nutrient and contaminant loads from materials applied to land, on the residues of pesticides and other substances in soils, and on the physical state of soils.

### Soils in the built environment

Land contamination needs to be tackled and sustainable drainage used to control flooding.

- Contaminated land is a risk to groundwater quality and a deterrent to redevelopment. It needs to be identified and treated more quickly.
- Companies should be encouraged to do more to prevent new contamination from chemical spillages.
- Sustainable flood management requires urban and rural land use to employ the natural flood control functions of the soil. Sustainable drainage techniques and farming practices that slow down runoff need to be promoted where appropriate.

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# Introduction

*"We know more of the movement of celestial bodies than about the soil underfoot"*

*Leonardo da Vinci's observation is still true today*

Healthy soils are vital to a sustainable environment. They produce food and timber, filter water, store carbon, support wildlife and the built landscape, and preserve records of our ecological and cultural past. But there are increasing signs that the condition of soils has been neglected. It cannot be assumed that soil loss and damage will be recoverable. It is therefore essential that soils are managed sustainably to keep them healthy for future generations.

## What is soil?

Soil covers most of the earth's land surface. It is the zone where plants take root and the foundation for terrestrial life and much of our economic production. It varies in depth from a few centimetres to several metres. Topsoil is the upper, more organically-rich layer, subsoil is the underlying layer.

Most soils contain sand, silt, clay, organic matter, water and air. The make-up of different soils determines the uses and activities they can support – the soil 'functions' (Box 1). Most soils perform several functions. A farmer may use soil to produce crops, but that soil may also help to regulate water flow, water quality and flooding, protect buried archaeological remains and support wildlife. Understanding and valuing these goods and services are crucial to good soil management. To achieve sustainable development, soil protection must be balanced with the other needs of society, the economy and other parts of the environment.

**Box 1. The six functions of soil[1]**

*Support of ecological habitat and biodiversity*
Soil has a biological value in its own right. It is an important habitat and gene reserve for an enormous variety of micro-organisms and larger soil-dwelling animals.

*Food and fibre production*
Soil is the growing medium for food, fibre, timber and energy crops, and forage crops that are the basis for livestock production. It stores nutrients and water, and supports root growth.

*Environmental interaction*
Soil is a crucial link between the atmosphere, geology, water resources and land use. It acts as a filter, attenuates and immobilises substances, and takes up, stores and releases atmospheric gases. Soil regulates water flow from rainfall to vegetation and groundwater, and influences river flows and flooding.

*Providing a platform*
Soil provides the foundation for building and other development. Natural landscapes reflect the different soil systems that they contain.

*Providing raw materials*
Soil holds billions of cubic metres of water and is a direct source of minerals and resources, such as brickearth, peat and topsoil.

*Protecting cultural heritage*
Soil stores and protects much of our cultural heritage, including archaeological remains.

“Many take soil for granted, perhaps because 80 per cent or more of people in England and Wales now live in urban areas.”

There is concern about air and water pollution but soil remains in the background, overshadowed by more visible countryside issues.[2] Soils can be resilient but the lesson of history is that, once damaged, they take hundreds if not thousands of years to recover. Much of Mesopotamia, the cradle of civilisation, was turned into a semi-arid wasteland as a result of poorly-managed irrigation.[3] Severe soil degradation is a pressing problem in many parts of the world today (Box 2). Soil is effectively non-renewable, so a precautionary approach to protection is needed. And yet knowledge of this vital resource is still patchy.

**Box 2. The global scene[4, 5]**

- An estimated 23 per cent of the world’s usable land area has been degraded to some extent, mainly by soil erosion caused by overgrazing, deforestation and agriculture.
- Sixteen per cent of the EU land area is affected by some form of soil degradation.
- The area of soil usable for cultivation has declined from 0.32 ha per person in 1975 to 0.25 ha in 2000. This is due to soil loss and population growth. The typical western diet requires 0.6 ha per person.
- Nearly half of Africa is at risk from desertification, severe water and wind erosion occur in India, China and other parts of Asia, and salinisation of soil is a major problem in Australia.

## The purpose of this report

The report has been prepared by the Environment Agency and summarises our assessment of the state of soils in England and Wales. It does not identify detailed responsibilities and actions but it has helped to inform the Environment Agency’s own priorities for action, which will be set out in its Soil Strategy. Other reports and programmes relating to soil include:

- The 1996 report[6] of the Royal Commission on Environmental Pollution that made 91 recommendations for the sustainable use of soil.
- National programmes to be set out by the Department for Environment, Food and Rural Affairs (Defra) in the First Soil Action Plan for England, and in the Soil Strategy for Wales being developed by the Welsh Assembly Government.
- The European Commission’s Strategy for Soil Protection planned for 2007, which has working groups on erosion, organic matter, contamination and monitoring.

Each section of the report covers one of the main functions of soil and highlights the issues that need to be addressed. It looks at the quality of soil, the pressures acting on it, and the impacts that these pressures are having on soil functions. The report is an overview of what is known about the state of soil but it is by no means comprehensive. The report is intended as a summary for policy makers, those whose work is linked in some way with soil and anyone who has an interest in soil. The reference list provides further details for those wanting more technical information.

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# The interdependence of soil, water and air

## Key points

- Soil must be protected in its own right, but meeting environmental objectives for water and air also depends on good soil management.
- Soil has a large capacity to protect water from harmful contaminants. To maintain this, soil needs protection from pollutants from a range of sources.
- Sustainable land management practices are required that are economically viable and environmentally responsible – especially in agriculture.

Soil, water and air are intimately linked. They interact chemically, physically and biologically. They must be considered together as one ecosystem to ensure that each is managed for the benefit of the environment and society as a whole. Water resources and flooding are discussed in more detail in sections 5 and 6 respectively.

## Soil and water

### *Erosion*

The erosion and deposition of soil occurs naturally, but human activity has accelerated the rates of erosion. In England and Wales, farmers usually consider the loss of soil by water-driven erosion to be unimportant, because of the limited effects on productivity. However, erosion moves some 2.2 million tonnes of arable topsoil annually and 17 per cent of soils show signs of erosion.[7] The loss of soil increases the need for soil conditioners and reduces the retention and filtering of water. The soil particles and their associated contaminants (that can include pesticides, nutrients, metals and pathogens) often end up in watercourses.

Eroded silt can smother river-bed gravels, harming aquatic plants, invertebrates and the eggs of fish. Trout spawning beds in 29 out of 51 river reaches surveyed across southern England contained more than 15 per cent of fine sediments, a threshold at which half the eggs and larvae are likely to die.[8] In the rivers Test and Itchen, for example, over 95 per cent of fine sediments came from the surrounding land, where arable crops are a major land use.[9] Erosion and deposition account for over half of the river maintenance activities in some Environment Agency Regions. The Environment Agency's annual bill for dredging in England is about £3 million.

*Flood water carrying eroded soil*

Water-borne sediments can also contaminate floodplain soils. In the flood plain of the Yorkshire Ouse, the soil contains heavy metals from two thousand years of metal mining in the Dales, with higher concentrations from mining and industrial sources since around 1750. The contamination may be significant for agricultural soil quality and, if remobilised, for river quality.[10]

In England and Wales, the main causes of structural damage and erosion in soils are:

- intensive cultivation, particularly when soils are compacted by heavy machinery or left exposed to heavy rain (as with winter cereals and maize);[11]
- heavy trampling of soil by sheep and cattle, and rooting by free-range pigs;
- poor forestry practice, for example during road construction and harvesting;
- runoff from urban land, especially building sites.

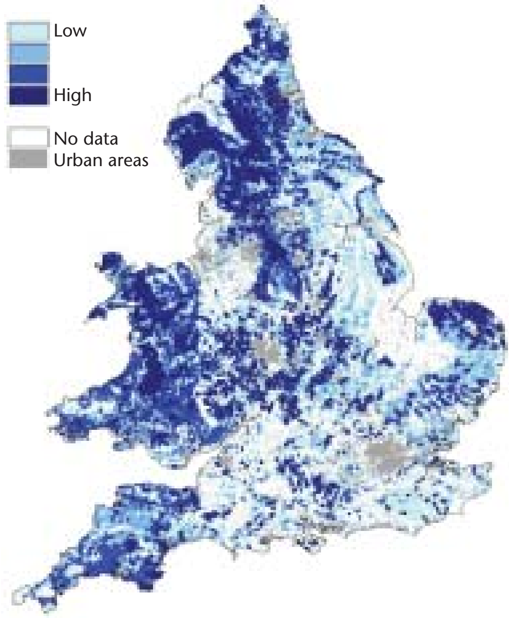
Annual losses from cultivated land are generally less than 5 t/ha but can occasionally exceed 100 t/ha – equivalent to a 1 cm thick layer of soil.[12] Such losses, from soils only 15 cm deep, are unsustainable.[13] The risk of erosion varies with soil type, slope, land use and timing of land management activities. A decline in organic matter content may have contributed to the problem. All rivers are vulnerable although those with salmon or other special conservation interests are of most concern. A significant proportion of soils are at risk if there is inappropriate soil management (Figure 1).[14] The extensive areas of low erosion risk are also important as they may lose more soil in total than high-risk areas.

Identifying practical soil management options to reduce erosion has to be undertaken on a case by case basis. Defra is piloting a new agri-environment scheme for England in 2005 aimed at reducing soil erosion. Erosion measures may also be included in a scheme being proposed for Wales.

## *Nutrient loss*

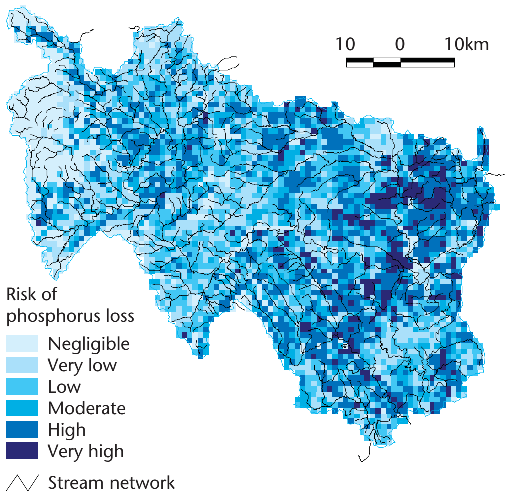
Farmland is a major source of water pollution by nitrogen and phosphorus, which are both plant nutrients. Most phosphorus lost to water is carried on eroded soil particles, while nitrate is lost mainly by subsurface leaching.[12] The pollution risk is increased when the timing of fertiliser applications is poor in relation to the needs of the crop or the weather conditions, and where the application exceeds the crop requirements (Section 4). The move to autumn-sown cereals has increased losses because winter rainfall can cause nitrate to leach from soil organic matter, and phosphate to be washed off. Heavy surface applications of slurry can also smother the soil surface so that nutrients are washed off into watercourses.

**Figure 1** Soil erosion risk in England and Wales




Source: McHugh *et al.*, 2002[14]

**Figure 2** Risk of phosphorus loss from soils in the River Wye catchment

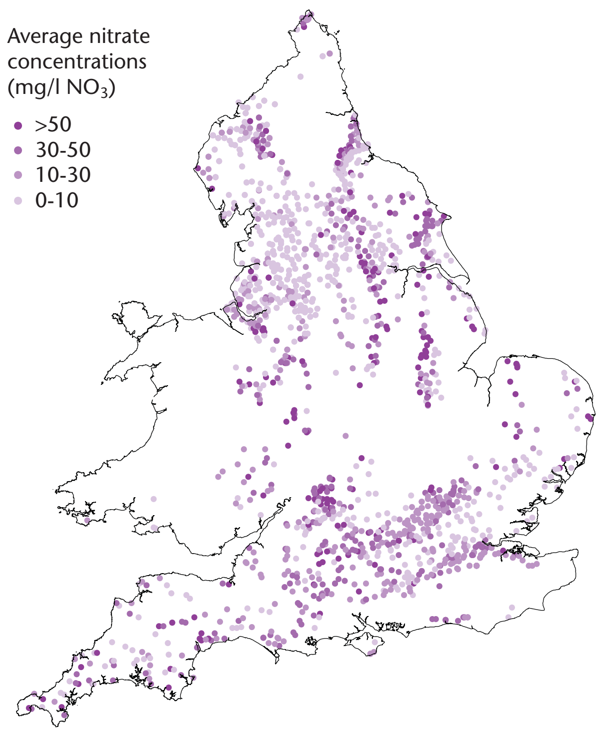



Source: Defra *et al.*, unpublished[19]

Agricultural intensification in England and Wales has resulted in a four-fold increase in phosphorus losses to water from cereal land between 1931 and 1991.[15] Combined with sewage inputs, this has led to widespread eutrophication of surface waters – increased growth of algae or other plants leading to habitat degradation, loss of biodiversity and fishery decline.[16, 17] More than half the rivers in England and Wales have artificially high phosphate concentrations (over 100 μg/litre).[18] Phosphorus loss depends on the same factors that affect erosion. Assessing and mapping levels of risk should allow control measures to be targeted (Figure 2).[19]

The loss of nitrate from agricultural soils is causing failure of the drinking water standard in some groundwater sources (Figure 3) and is contributing to eutrophication in estuaries and the sea.[16, 17] Some 55 per cent of England and three per cent of Wales have been designated as Nitrate Vulnerable Zones, where farmers must follow an action programme to reduce nitrate pollution. However, the measures only reduce nitrate leaching slightly and further controls are needed in many areas.[17] Good farming practices[20] for reducing nutrient pollution have not been widely adopted.

**Figure 3** | Nitrate concentrations in groundwater, 2000 to 2003




Source: Environment Agency

Local partnerships between landowners, farmers, local authorities, the Environment Agency and others are encouraging sustainable farming practices. Schemes include LandCare projects on the Test, Itchen and Hampshire Avon, the River Parrett Catchment Project and the Cornwall Rivers Project (Box 3). To achieve the water quality improvements required by the Water Framework Directive, diffuse pollution from agricultural land will have to be addressed (Section 4).[21]

**Box 3. Case study: Cornwall Rivers Project, 2002 to 2004[22]**

A number of rivers and fisheries in Cornwall are affected by soil erosion and deposition from livestock and arable farms. The Cornwall Rivers Project is aiming to restore river quality and contribute to the economic viability of local rural communities by promoting sound land use practice and awareness of water resource issues. It is targeting 10 rivers, including the Camel, Ottery, Fal and Fowey. It aims to:

- provide advice and training on reducing soil loss to several hundred farmers and landowners;
- reduce erosion at over 60 sites;
- fence 100 km of vulnerable watercourses;
- develop seven demonstration sites.

The project is led by the Westcountry Rivers Trust with support from the Environment Agency and others.

## Soil and the atmosphere

### *Climate change*

UK soils store some 10 billion tonnes of carbon. This is more than the annual global emissions of carbon dioxide. Changes in land use, such as draining peat and converting grassland to crops, release carbon dioxide by oxidising soil organic matter. Such land-use change accounts for about five per cent of UK greenhouse gas emissions. Carbon uptake by farming and forestry is equivalent to about two per cent of UK emissions and could be increased, for example by planting more woodland and energy crops.[23] Some of this uptake can count towards the UK's commitments to reduce emissions under the Kyoto Protocol.[24]

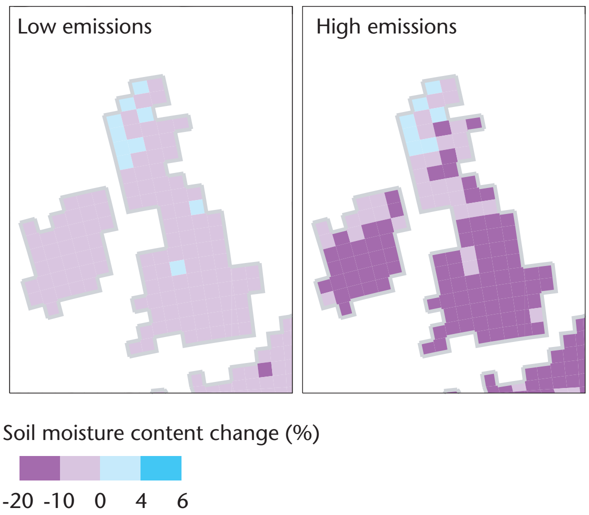
Nitrous oxide from soils contributes four per cent of UK greenhouse gas emissions. Its formation is increased when inorganic nitrogen fertilisers and manures are added to soil. The reduction in nitrogen fertiliser use since 1990 has reduced nitrous oxide emissions.[24]

Climate change could have profound effects on soils, both directly and by stimulating changes in land use. Agriculture will change with shifting rainfall patterns, temperature, sunshine hours and soil quality. The implications for soils are hard to predict:[25, 26]

- The accumulation and loss of soil carbon will change with soil temperature and moisture. The net effects are uncertain but change is most critical in peatland and other organic-rich soils that are a major store of soil carbon.

- Acidification and the movement of nutrients and other contaminants to water will also change with rainfall and temperature.
- The release of more dissolved organic carbon from upland soils may cause a worsening of colour problems in water supplies.[27]
- Arable farming, with its attendant pressures on soils, could expand in the north and west.
- Erosion risks will increase if the trend of wetter winters and more intense rainfall continues; drier soils in the summer would accelerate runoff.
- More demand for irrigation is likely where soil water deficits increase, especially in southern England (Figure 4).[28]

**Figure 4** Projected change in soil moisture by 2080



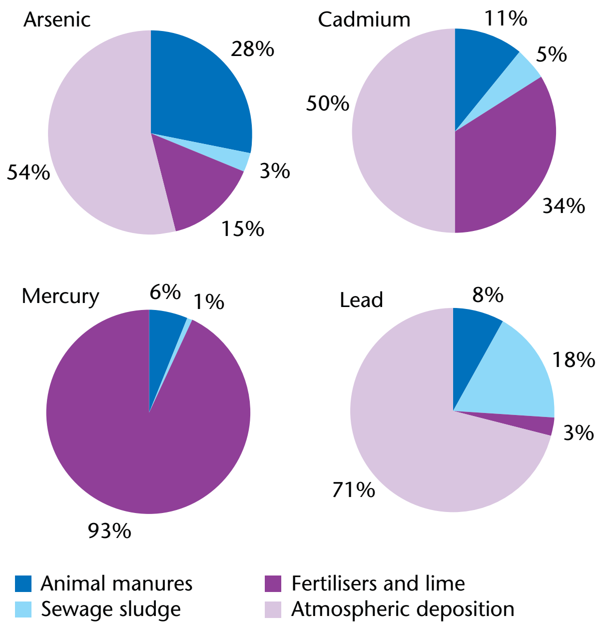

Source: Hulme *et al.*, 2002[28]

## *Air pollution*

Deposition from the air causes widespread soil contamination by sulphur and nitrogen (Section 4), heavy metals and persistent organic chemicals. Between 1995 and 1997, 20 to 90 per cent of metal inputs to agricultural soils, including lead, cadmium and arsenic, came from the air (Figure 5).[29] Locally high levels of deposition to soil occurred in the past, for example of PCBs and dioxins around waste incinerators, and heavy metals downwind of metal smelters.[30] Near smelting works at Avonmouth, high soil concentrations of zinc were linked to an absence of earthworms.[31] Emissions to air of most metals and organic chemicals have fallen since the 1980s, but soil contaminant concentrations remain high in some urban-industrial areas (Section 6).[32]

Once deposited on soils, air pollutants and their effects can take decades to dissipate. In its regulation of industrial emissions, the Environment Agency aims to ensure that contaminants from aerial sources will not build up further in soils.

**Figure 5** Sources of heavy metal inputs to agricultural soils in England and Wales, 1995 to 1997




Source: MAFF 1998[29]

3

# Soil, wildlife and biodiversity

## Key points

- The biodiversity of soil organisms plays a vital but poorly understood role in maintaining healthy soils.
- Many semi-natural habitats in England and Wales are suffering from soil-related problems, including nutrient enrichment, acidification and erosion.
- Better understanding is needed of the nature and importance of soil biodiversity for agriculture, nature conservation and environmental protection.

Soils contain vast numbers of organisms and species, forming a biodiversity that far exceeds that above the ground. The bacteria, fungi, invertebrates and other soil organisms are valuable in themselves – over 100 species of soil invertebrates and fungi are included in the UK Biodiversity Action Plan.[33] They also perform functions which are vital for healthy soils and for the habitats and uses that depend on them.[34] Soil organisms:

- drive processes including soil formation, nutrient cycling and nitrogen fixation, the breakdown and retention of organic matter and carbon, and the maintenance of soil structure;
- break down chemical contaminants and pathogens, so helping to protect water quality and restore contaminated soils;
- include symbiotic soil fungi on which many plants depend;
- include the underground life stages of many valuable insects, such as pollinators and pest predators;
- are food for wildlife such as mammals and birds;
- are a potential source of pharmacological compounds.

Sustainable soil use must preserve and restore these different functions to support agriculture, environmental protection and nature conservation.

## Soil organisms

Soil organisms include bacteria, fungi, single-celled protozoa and larger invertebrates.

There are tens of thousands of species of bacteria in a typical soil type but perhaps 99 per cent have not yet been identified.[35] Knowledge is lacking about the role of soil microbes in keeping soils healthy and how these microbes are affected by climate, fertilisers, pesticides, heavy metals and other factors. Most pesticides appear to have a temporary effect on soil microbial populations, although the effects of the bulk disposal to land of waste pesticides such as sheep dip are unknown. Research using new molecular techniques suggests that repeated applications of persistent pesticides may reduce microbial diversity and possibly function.[36]

Mites (Acari) and springtails (Collembola) are often the most abundant invertebrates in soil; worms (Oligochaeta) and roundworms (Nematoda) are also numerous. These invertebrates help to process and incorporate organic matter into the soil. The majority of species have yet to be identified. Identifying soil fauna is a specialist and labour-intensive activity, so techniques like molecular genetics and digital image recognition are being developed. The distribution of invertebrate groups is being investigated to develop baselines and indicators of soil quality.[35] Biological activity is influenced by factors such as geology, rainfall, temperature and acidity, and contaminants or inappropriate management may degrade these ecological systems and their soil functions.

As with other wildlife communities, soils are vulnerable to the introduction of alien species such as the New Zealand flatworm, *Arthurdendyus triangulatus*. This predator of earthworms has spread through northern England since the 1960s, although its ecological impact is unknown.[37]

## Area of habitats

Soil is one of the building blocks that defines the natural vegetation and character of the landscape.[38,39] Over the past century or more, large losses of some habitats to agriculture and development suggest that substantial degradation of soils and their biodiversity has occurred. Semi-natural habitats, such as broadleaf woodland, heath and unimproved grassland, occupy 19 per cent of England and Wales,[40] but some 97 per cent of neutral grassland (such as hay meadows) has been lost since 1930, and 84 per cent of English heathland has been lost since 1800.[41, 42]

Urbanisation and intensive agriculture continue to affect the area and quality of soils and habitats. Between 1990 and 1998, developed land increased by 3.5 per cent in rural areas, to cover 13.5 per cent of England and Wales. There was also much exchange of land between habitat types: a net increase in arable area of one per cent resulted from a 12 per cent loss and 13 per cent gain.[40] This turnover means, for example, that more land may be affected by the pressures of arable use than just the land that is under crops at any one time.

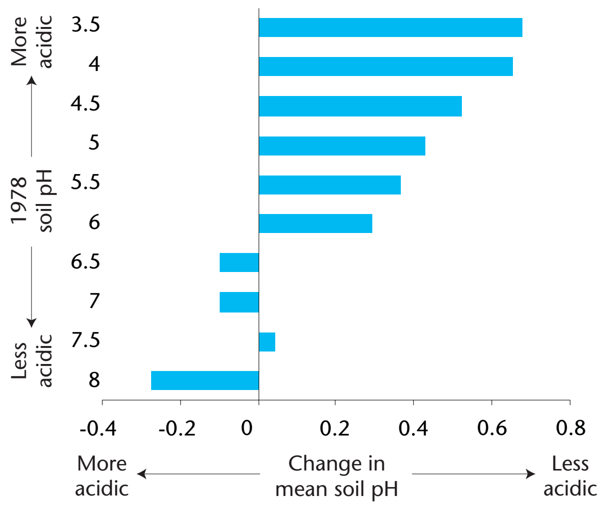
## Habitat quality

There are 35 terrestrial and freshwater priority habitat types in the UK Biodiversity Action Plan. Most are adversely affected by soil-related problems as well as other impacts.[33] Many habitats are suffering or at risk from changes in land use, agricultural nutrient runoff, soil erosion or coastal erosion. Soil problems are not the only cause but, in England, substantial proportions of grasslands and other broad habitats were not in favourable or recovering condition in 2002.[43] Some 43 per cent of freshwater wetland Sites of Special Scientific Interest (SSSIs) in England are in unfavourable condition, with nutrient and sediment runoff a factor in most cases.[43]

Many areas suffer from soil acidification or nitrogen enrichment. Air pollutant deposition exceeds harmful levels, or 'critical loads', for acidity and for the nutrient effects of nitrogen over 80 per cent and 95 per cent respectively of habitats sensitive to these inputs (Figure 6).[44] The pollution loads of acidity and nitrogen have fallen over the past one to two decades[45] and soil acidity has decreased over the 20 years to 1998 (Figure 7). But there has been a continuing decline in species diversity of infertile grassland between 1990 and 1998, indicating nitrogen enrichment which favours more competitive species (Figure 8).[40] Further cuts in industrial and transport emissions are expected up to 2010, but recovery of soils and ecosystems is expected to take decades.[45]

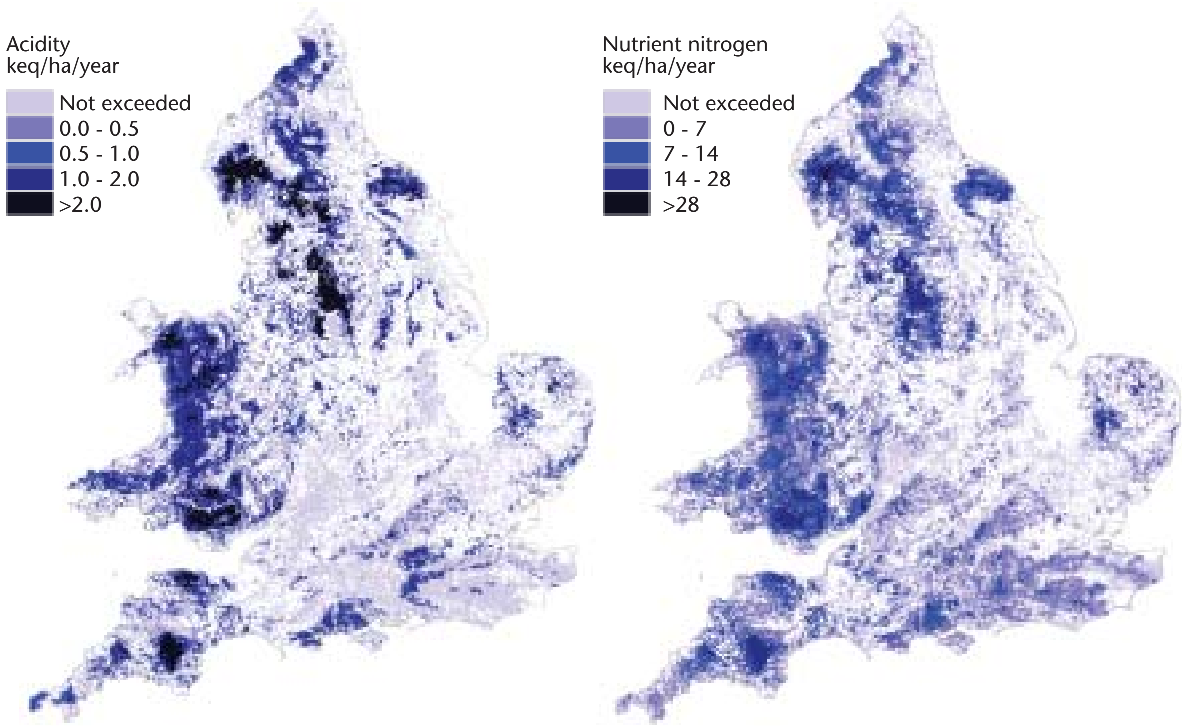
**Figure 6** See page 12

**Figure 7** Changes in mean soil acidity in Great Britain between 1978 and 1998



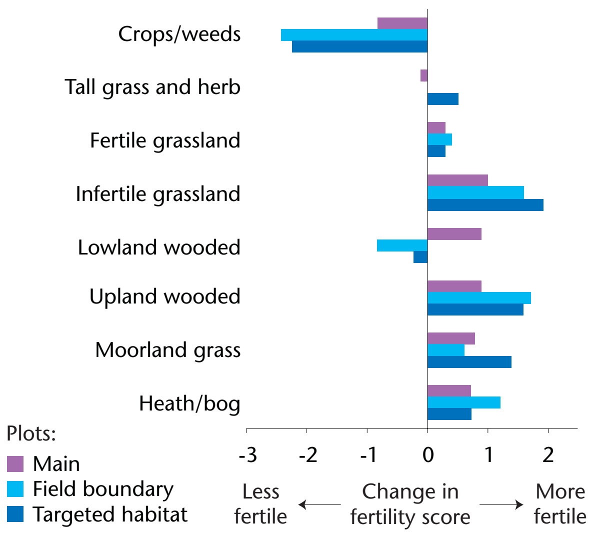

Source: Haines-Young *et al.*, 2000[40]

**Figure 6** | Exceedance of critical loads for acidity and nutrient nitrogen, 1995 to 1997




Source: CEH, 2003

**Figure 8** | Changes in the mean fertility score of vegetation in Great Britain, 1990 to 1998




Source: Haines-Young *et al.*, 2000[40]

Table 1 | Agri-environment schemes in England and Wales by area[46, 47]

| England schemes (2002) | area (thousand ha) | Wales schemes (2002) | area (thousand ha) |
|---|---|---|---|
| Environmentally Sensitive Areas* | 620 | Environmentally Sensitive Areas | 180 |
| Countryside Stewardship | 322 | Tir Cymen (2000) | 89 |
| Arable Stewardship | 2 | Tir Gofal** | 97 |
| Organic Conversion | 158 | Organic Conversion | 49 |
| Nitrate Sensitive Areas | 4.8 | - | |
| Habitat | 7.1 | Habitat | 6.8 |
| Moorland | 2.7 | Moorland | - |
| Woodland schemes | 45.9 | Woodland schemes | - |
| Total | 1,163 | Total | 422 |
| Total share of non-urban land | 10.0% | Total share of non-urban land | 20.4% |

*Hectares currently in agreement

**The whole-farm scheme in Wales, replaces Tir Cymen and Environmentally Sensitive Areas

## Habitat protection

Agri-environment schemes covered about 10.5 per cent of England and Wales at a cost of about £204 million in 2002 (including SSSI management payments) (Table 1).[46] Soil is usually not an explicit target of these schemes, but more environmentally sensitive management should benefit soil quality and biodiversity (Box 4). Organic farming for example, if managed well, should help soil quality and biodiversity by applying less pesticides and inorganic fertilisers. Agri-environment schemes need to incorporate specific measures that target soil protection where this is necessary.

The Environment Agency authorises thousands of water abstractions, discharges, waste management licences and other permissions that could affect soils. It is currently undertaking a comprehensive review of all permissions that may affect sites designated under the EC Habitats Directive to ensure that conservation features are not being harmed.

Land-use planning is key to protecting soils, habitats and landscapes but this is hampered by a lack of access to information on soils. In Wales, most local authorities use the LANDMAP (Landscape Assessment and Decision Making Process) system to guide planning policy; this includes information on biodiversity and visual features but currently lacks data on soils.

### Box 4. Case study: Profit, Biodiversity and the Environment - the PROBE project[48]

In a difficult period for farm incomes, this project aims to show how farming can both make a profit and help wildlife. A 60 ha site in Farmcare's Stoughton Estate near Leicester has been divided into 14 plots that compare conventional farming with techniques such as minimum tillage, varying spray regimes, watercourse protection measures and organic farming. It is supported by Farmcare (a farming company), Defra, the Environment Agency and RSPB.

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# Producing food and fibre

## Key points

- The intensification of agriculture has boosted productivity but increased pressure on soils. In some areas, the organic content of soils has declined and soil structure has been damaged. Better farm management is needed to decouple productivity from impacts on soil quality.
- Soil nutrient levels have increased but the effects on soils of fertiliser and pesticide inputs are not well understood. Applications of fertilisers, manures and wastes must all be taken into account to control nutrient loading.
- The inputs and potential build-up of heavy metals and persistent organic chemicals in soils need to be assessed so that all sources can be appropriately managed.

Healthy soils are essential for food and fibre production. These industries are in turn vital to the social and economic welfare of the countryside. The intensification of agriculture since the Second World War, driven by society, the markets and government policies and production subsidies, has caused much of the soil-related environmental degradation seen today. The national strategies for sustainable farming in England and Wales recognise the need to find a new balance that serves the consumer, gives farmers a fair return, and ensures environmental sustainability.[49,50]

## Agriculture

Farming accounts for about three-quarters of the land in England and Wales and British farmers produce more than half of all the food we eat today. The intensive use of a high proportion of the land has had increasing impacts on the soil (Table 2). Given the burgeoning world population and the average western diet, which requires 0.6 ha of productive land per person compared with the 0.3 ha per person that is available globally and in England and Wales, world food production will have to increase further. It is essential that increasing productivity does not increase resource use and environmental impacts.

The European Union's Common Agricultural Policy (CAP) is critical to the relationship between farming and the environment. The 2003 CAP reform began the process of decoupling subsidies from production. The UK has opted for complete decoupling from 2005. From 2005, for the first time, the main subsidies will be explicitly linked to compliance with EU standards for the environment, public and animal health, and animal welfare. Farmers will also have to maintain land in good agricultural and environmental condition. This should lead to improvements in soil structure, organic matter, erosion and habitat protection. To help farmers meet their obligations, Member States must set up a farm advisory service by 2007. In Wales, the Farming Connect Advisory Service is already providing advice on good farming practices. In England, a service could be linked to schemes such as the whole-farm approach being developed by Defra. However, only five per cent of spending has been agreed for rural development, including agri-environment schemes (Section 2), up to 2011.

### *Arable crops*

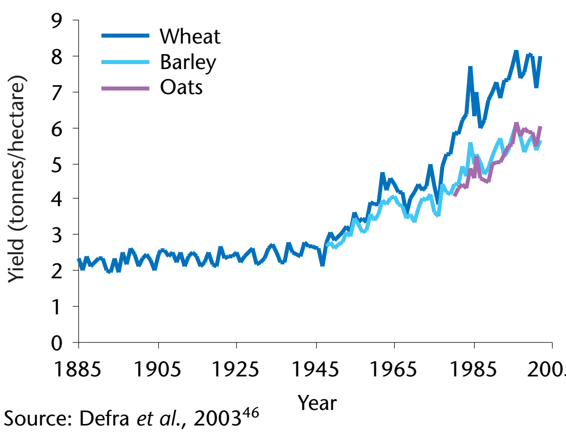
Intensive arable crop production is often linked to soil erosion, loss of soil organic matter and pollution from

**Table 2** | Agricultural trends bringing pressures on soils

| Activity | Pressure | Trend in England and Wales |
|---|---|---|
| Specialisation of agriculture | Reducing the diversity of the landscape and hence wildlife | Only 12,000 (7%) mixed farms in 1998, declining to 10,961 by 2002[51, 52] |
| Increased farm size | Allows more mechanisation and intensification | Average farm size increased by 84% between 1945 and 1998[53] |
| Mechanisation | Soil compaction and erosion. Increased field size, removal of hedges, trees and ditches | Field size increased by between 39% and 182% from 1945 to 1983 in seven study areas in England[54] |
| Intensification of livestock farming | Increased grazing pressure, more fertilisers and pesticides, silage production, increasing erosion risk and declining biodiversity in uplands | The sheep population rose by 80% from 1970 to more than 31 million in 1999; since 2000 numbers have fallen to about 25 million. In Wales, from 1974 to 1995, silage production increased four-fold to 228,000 ha, and hay production more than halved to 94,000 ha[50] |
| Intensification of arable farming | Loss of permanent grassland, winter cereals, reduction in soil organic matter, higher erosion risks, more fertilisers and pesticides | Area of lowland grassland declined by 97% between 1934 and 1984. |
| Land drainage | Loss of wetlands and peat | Drainage peaked at 100,000 ha/year in the mid-1970s[55] and there is little reversion |

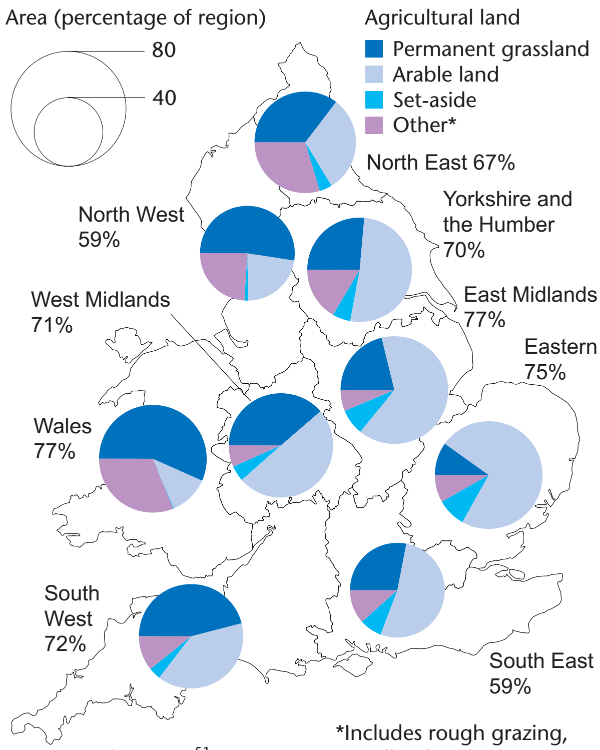
fertilisers and pesticides (Section 2). The intensification is shown by the yield of wheat, which has trebled over the past 50 years (Figure 9). This has been achieved through plant breeding, cultivation techniques, modern machinery, land drainage, fertilisers and pesticides. The area of UK cereals has doubled over the past 50 years, although there is strong regional variation, with arable land occupying 25 per cent of eastern England but just three per cent of Wales (Figure 10). Over the past 30 years, farm expenditure on energy has risen five-fold, on fertilisers three-fold and on pesticides twenty-fold, indicating that increasing productivity is associated with higher inputs and pressures on soil (Figure 11).[46]

**Figure 9** | Crop yield for wheat, barley and oats in the UK, 1885 to 2002




Source: Defra *et al.*, 2003[46]

**Figure 10** | Regional differences in agriculture in England and Wales, 2002

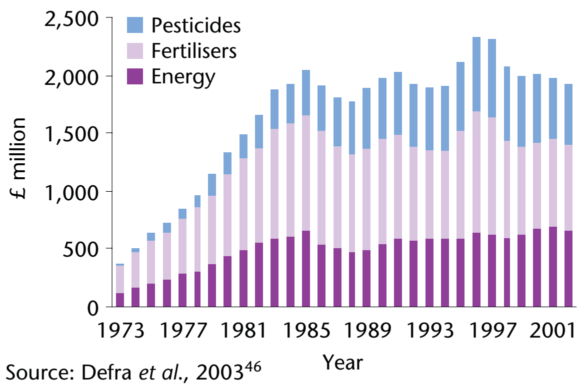



Source: Defra, 2003[51] and NAW, 2003[52]

*Includes rough grazing, woodland and other uses such as roads and buildings

Intensive arable cultivation can damage soil structure through compaction, the creation of fine seed beds, and reduced levels of organic matter and biological activity. Coupled with poor plant cover this increases the likelihood of soil loss. The move to winter cereals and the expansion of maize cropping have contributed to the increasing erosion risks (Section 2).[12]

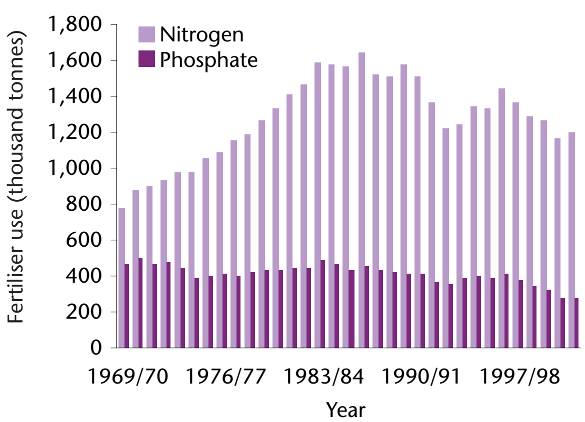
**Figure 11** Farming expenditure on energy, fertilisers and pesticides, 1973 to 2002 (at 2002 prices)




Source: Defra *et al.*, 2003[46]

Between 1990/91 and 2001/02, the use of inorganic nitrogen and phosphorus fertilisers in the UK fell by 21 per cent and 30 per cent respectively (Figure 12). However, the majority of arable farms still operate a nutrient surplus. The nitrogen excess has been reduced to about 25 kg/ha/year[56] while the average phosphorus surplus is about 16 kg/ha/year.[57] This excess can build up in the soil (see below) and cause water pollution. Phosphate fertilisers also contain variable amounts of the heavy metal cadmium, which may accumulate in the soil with risks to the environment and the food chain. There are European Commission proposals to restrict the levels of cadmium permitted in fertilisers.[58]

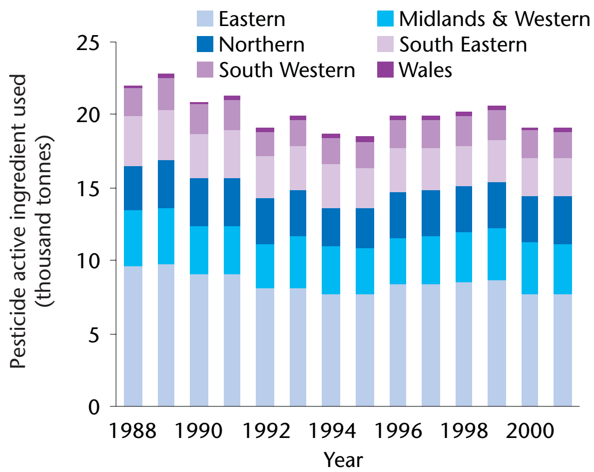
**Figure 12** Inorganic fertiliser use in England and Wales, 1969/70 to 2001/02




Source: Fertiliser Manufacturers Association, 2003[56]

Changes in pesticide use reflect changes in crops, agricultural practice and the pesticides on the market. The weight of pesticides used in England and Wales has changed little over the past decade but the potential for damage to the soil from the changes in their active ingredients is largely unknown (Figure 13).[59] The area of land registered for organic production, which restricts the use of pesticides and inorganic fertilisers, had increased to nearly two per cent of agricultural land by 2002.[46, 47] The Voluntary Initiative (2001 to 2006), led by the Crop Protection Association, aims to reduce the impact of pesticides on the environment through measures taken by farmers. The programme was accepted by the Government in place of a proposed tax on pesticides and its success will determine whether or not additional controls are required.

**Figure 13** Agricultural usage of pesticides in England and Wales, 1988 to 2001



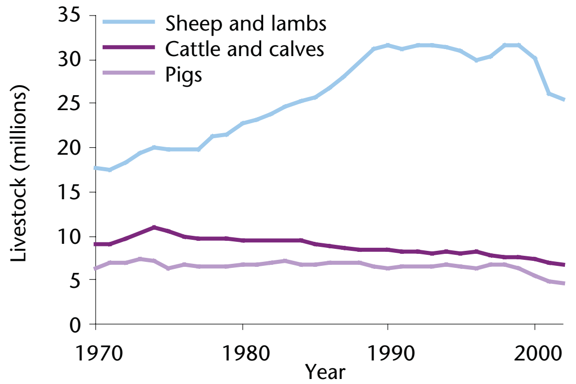

Source: Defra

## *Livestock*

The number of livestock in England and Wales peaked at nearly 38 million in 2000 (Figure 14). Numbers fell to about 32 million in 2002, partly due to the Foot and Mouth outbreak and partly due to the cut-back in subsidies. High densities of sheep and cattle cause overgrazing, which leads to soil erosion from exposure and compaction of the soil surface. This can be worse where stock spends the winter outside and where movements are concentrated at access points. In the uplands, overgrazing is a concern for the conservation of terrestrial plants and wildlife.[60] Outdoor pigs, although far fewer, can cause intense soil damage and erosion.

The average application of nitrogen fertiliser to grassland has fallen in the past decade to about 100 kg/ha/year, but it is still often surplus to crop requirements.[12] The switch from hay to silage production and the taking of two or three crops instead of one per season have increased the pressure on soils from fertiliser additions.[50] Intensive livestock units have increased efficiency but have brought other localised pressures on soils, such as those associated with high ammonia deposition and the disposal of manure and slurry.

**Figure 14** Livestock on agricultural holdings in England and Wales, 1970 to 2002




Source: Defra, 2003[51] and NAW, 2003[52]

## Forestry

The British market for all timber products is about 47 million m³ per year. British forests now produce about seven million m³ per year and this is expected to rise to 16 million m³ per year by 2025. Forests and woodland cover eight per cent of England and 13 per cent of Wales. Government policy is for this area to be expanded.[61, 62] Woodland will generally safeguard and enhance soils, for example by reducing soil compaction and increasing water infiltration.[63] In the past, poor management or conifer planting in inappropriate areas damaged some upland soils in Wales and elsewhere, causing erosion and enhancing soil acidification.

Practice has greatly improved in the past two decades. The proportion of broadleaf planting and continuous cover systems is increasing, and all public forest is now certified as following sustainable management practices. Forestry should comply with the UK Forestry Standard and guidelines for good environmental practice to maintain natural resources, including the soil.[64] Planting is recognised as providing multiple benefits, including the restoration of land damaged by industry and mineral extraction.[61, 62]

## Manure, slurry and waste applied to land

Manure and slurries from livestock are a valuable source of plant nutrients and organic matter to maintain soil quality. Around 110 million tonnes/year of livestock excreta are produced in England and Wales, much of which is spread to land. This material contains about 0.5 million tonnes of phosphate and 0.8 million tonnes of nitrogen.[66] This is about double the amount of phosphate and equal to the amount of nitrogen applied in inorganic fertilisers, so it needs to be managed carefully on both conventional and organic farms. Manure and slurry also contain metals, such as copper and zinc, which need to be managed to avoid damaging microbiological processes and some crops. All pig and poultry installations (with at least 40,000 birds, 750 sows or 2,000 production pigs) regulated under the Pollution Prevention and Control Regulations must have a management plan to minimise the pollution risks if they spread manure and slurry to land.

Some controlled wastes can be spread to land for agricultural or ecological benefits, as long as the wastes are not a pollution or health risk. There is a lack of collated data on the amount and quality of this waste, but an estimated 4.5 million tonnes of industrial waste is recovered to land each year. The paper and food and drink industries are major sources. Conditions applied through the waste regulations should prevent any long-term build-up in soils of contaminants, but this also depends on responsible management. This route for recovery of value from waste may become more important as industries seek alternatives to landfill.

The use of sewage sludge reduces the need for inorganic fertiliser and helps to maintain levels of organic matter in soils. In 2000, 59 per cent of the 940,000 tonnes of sludge produced in England and Wales was recycled on one to two per cent of agricultural land (Environment Agency data). Regulations control application rates and heavy metal inputs, and further food safety concerns have been addressed by a voluntary agreement (the 'Safe Sludge Matrix') involving the water industry, British Retail Consortium, Defra and the Environment Agency. Under the agreement, the use of untreated sludge on food crops has been phased out and there are further controls on the use of treated sludge.[67] The provisions of the agreement are to be incorporated into the revised Sludge (Use in Agriculture) Regulations.

Spreading sewage sludge and controlled wastes on land is often the best practicable environmental option to recover these materials and benefits soils.

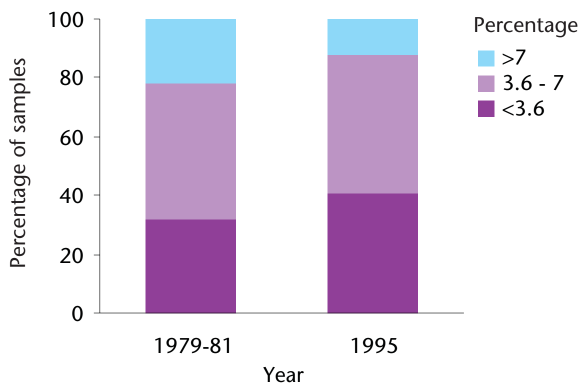
However, care is needed to avoid detriment to the soil and other environmental media. All inputs must be accounted for by land managers so that safe loading limits of nutrients and contaminants are not exceeded.

## The quality of agricultural soils

Soil is a farmer's key asset. Good soil husbandry should help to maintain yields and reduce the costs of soil damage both on and off the farm.

The organic matter content of soil is a key indicator. It is a food supply and habitat for soil organisms, maintains soil structure, holds and recycles nutrients and retains pesticides and other chemicals, allowing some to be broken down biologically. Between 1979-81 and 1995 the organic matter content of agricultural topsoils in England and Wales fell by an average of 0.5 per cent (Figure 15). This may be related partly to the conversion of grasslands to arable use and partly to dilution caused by deeper ploughing.[68] This loss may not be significant for crops, as the organic content of most farmland soils remains above the suggested critical threshold of two per cent, but it may affect other functions.[69] In the case of fenland peats, oxidation of organic matter exposed by ploughing has lowered the land surface and reduced their value to agriculture.

**Figure 15** Organic matter in agricultural topsoils in England and Wales, 1979-81 to 1995

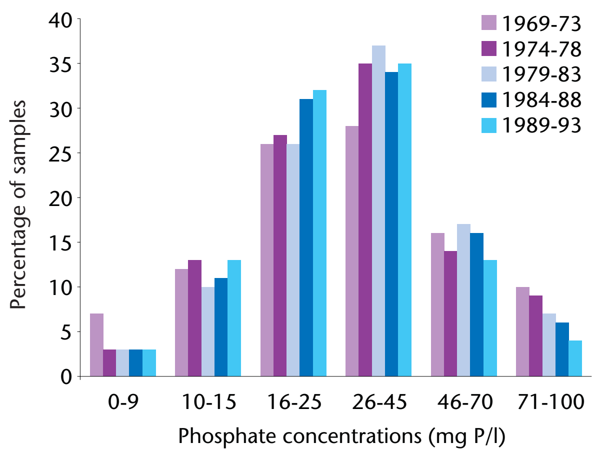



Source: SSLRC, National Soil Inventory

Soil can suffer structural damage, such as compaction, capping or erosion, from poor timing of cultivation, overworking of soils or over-stocking. Several case studies indicate that these problems are widespread as a result of arable intensification.[12]

The percentage of soils with very high concentrations of phosphorus has decreased, but levels in lower fertility soils have risen in order to meet targets for crop growth, and this may have increased the risk of water pollution (Figure 16).[70]

**Figure 16** Arable soil phosphate levels, 1969 to 1993




Source: Skinner *et al.*, 1992[70]

Knowledge of pesticide residues in soils and their effects on soil health and other organisms is limited.[59] Other persistent organic chemicals from aerial pollution are generally at low and declining concentrations in most agricultural soils.[30] UK dioxin emissions, for example, have been greatly reduced over the past decade and levels of dioxins and dioxin-like PCBs in the human diet fell by half between 1997 and 2001.[71]

The concentrations of metals in rural soils vary widely and changed little between 1978-82 and 1995.[68] Calculations suggest that some heavy metals could gradually build up in soils and so the risks to crops, the food chain and ecosystems may need further assessment.[29]

5

# Providing raw materials

## Key points

- Soils are damaged by the extraction of minerals and fossil fuels. There is a legacy of affected sites that need careful restoration.
- Soil needs to be seen as a valuable raw material, to be protected by the planning system and during the life and restoration of mineral extraction and other development sites.
- Water flows and resources are altered by the effects on soil of mineral extraction, construction and land use. These impacts need to be understood and managed.
- Peat is essentially non-renewable and is a major store of carbon. Efforts to develop and market renewable alternatives should be accelerated.

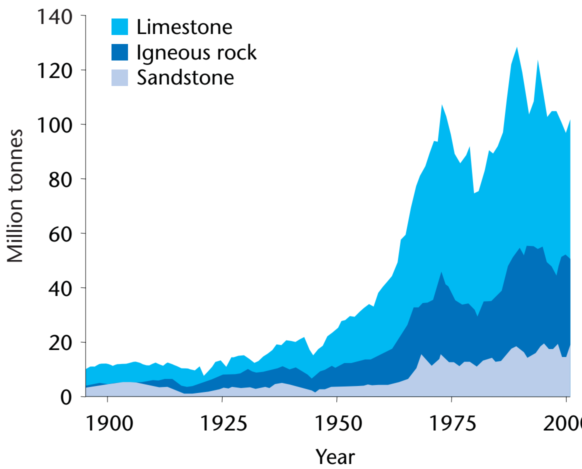
Soils overlie mineral and fossil fuel resources. Extracting these resources can severely disrupt the soil ecosystem by moving and mixing soils and vegetation that have developed over hundreds or thousands of years. Soils also intercept most of the rain that eventually becomes drinking water and can affect the recharge of surface and groundwater resources.

### Mineral extraction

Large volumes of soil are moved during construction (Section 6) and mineral extraction. In the UK, 330 million tonnes of minerals and coal are extracted annually. In 2000, a further 612 million tonnes of soil and rock were moved but not used, including overburden in mines and quarries and material shifted during construction ('hidden' material flows).[72] Aggregate production in the UK has increased dramatically over the past fifty years (Figure 17).[73] While metal mining has virtually ceased, the historical industrial activities in areas like Cornwall and Wales have left numerous spoil heaps and soil contaminated with heavy metals.

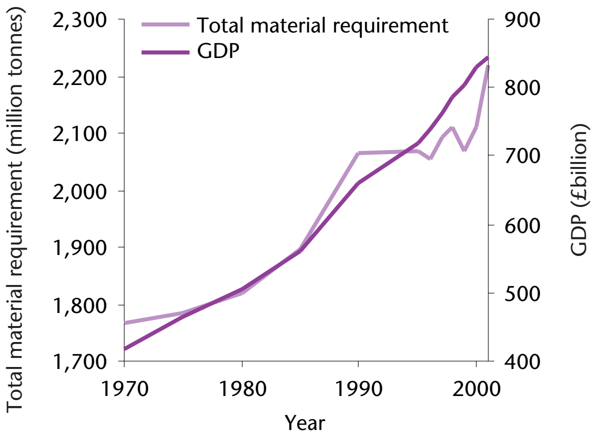
Over the past decade the total consumption of minerals has not changed a great deal, apart from an increase in 2001 (Figure 18). This is despite substantial economic growth, so in relation to economic output, the UK's material efficiency has improved. But we use 11 tonnes of raw materials per person per year (excluding water), or 35 tonnes including the hidden material flows of soil and rock.

**Figure 17** Production of aggregate in the UK, 1895 to 2001




Source: British Geological Survey, 2003[73]

**Figure 18** Total material requirement and GDP in the UK, 1970 to 2001




Source: ONS, 2003[72]

All this activity places pressure on soils, as the disturbance of soil, rock and vegetation contaminates and disrupts soil-vegetation ecosystems that may never fully recover:

- Soils may be built over, or stripped and stored for reuse and restoration. Some degradation of the soil is inevitable although good practice can minimise the damage.[74]
- Soils are buried and contaminated by spoil heaps, chemicals and fuel spills. In Wales there are records of over 1,300 metal mines and in 1999 some 108 km of rivers failed to meet quality targets due to contamination from old mine tips and discharges.[75]
- The removal of soil or alteration to its structure disrupts water flows within and downhill of the site.

Planning permission is needed for mineral and peat extraction. Extraction proposals have to include plans for storing and reusing the soil, and for restoring the site. Technical advice notes provide guidance but best practice needs further development. Planning policy, the aggregates levy and the landfill tax aim to reduce demand for aggregates by encouraging the reuse of materials from construction and demolition.

High quality restoration and aftercare can give good results. Restoring land to agricultural use has been fairly successful in workings planned since the mid-1980s.[76] Conversion to woodland has also been successful in a number of cases. Restoration of the soil and vegetation for habitat conservation is often required but significant loss of quality is almost inevitable.[24] Some sites have become valued in their own right, such as the slate mines of north Wales and mine tips with metal-tolerant vegetation.

## Peat

Peatlands in England and Wales are internationally important to conservation and preserve historical records of archaeology and ecology. They are also a major store of carbon which can contribute to greenhouse gas emissions (Section 2). In England and Wales, blanket bog has been reduced by conifer plantations to a current level of 2,850 km$^2$. Lowland raised bog is the main source of peat and only 13 km$^2$, some three per cent, remains.[33]

Some 3.4 million m$^3$ of peat are used annually in the UK, two-thirds by amateur gardeners.[77] Alternatives made up 36 per cent of the market in 1999, with a Government target of 40 per cent by 2005. The development and promotion of alternatives are needed to conserve peatlands, although the industry favours peat dilution.[78] The aim of planning policy is to reconcile peatland conservation with horticultural demand. Apart from protecting the remaining areas of peat, careful management and site rehabilitation are needed to limit the impacts of existing workings.[79] If demand is not reduced this may increase imports and transfer the problem to other countries.

## Water resources

Soil type and land use determine how much rainfall percolates into soils and the underlying groundwaters. The recharge of groundwaters varies by up to 80 per cent with soil type, and land-use practices add to this variation.[80] Agricultural drainage and damage to soil structure can increase surface runoff at the expense of groundwater recharge. Planting a conifer forest on an upland catchment may reduce the water reaching rivers and reservoirs.[81] The removal or sealing of soil during mineral extraction or development can radically alter recharge or water flows to neighbouring habitats. Soil erosion can also directly reduce surface water resources – eroded sediments have reduced total reservoir capacity in Yorkshire by seven per cent, a volume equivalent to that of the new Scammonden reservoir.[82]

As groundwaters provide up to 70 per cent or more of water resources in parts of England, impacts on subsurface flow could be important for water availability and river flows. These effects are often not clearly accounted for in land-use planning.

6

# The built environment

## Key points

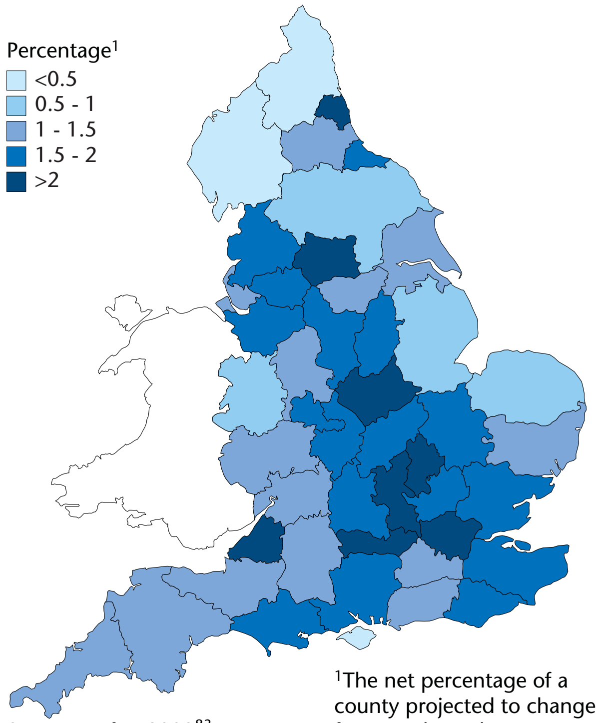
- Many flooding problems are made worse by ignoring the water retention function of soils. Sustainable urban and rural drainage practices are needed that work with the natural soil hydrology.
- Planning controls are not protecting soils adequately. Better information on soils is needed so that development minimises the permanent loss of valuable soil functions.
- The identification and treatment of contaminated sites needs to be accelerated to help the redevelopment of brownfield sites.

Soils are a platform for building but in urban as well as rural areas they also have other vital functions in flood control and in open spaces such as parks, gardens and allotments. Urban soils often contain important archaeological remains. Soils allow rain to be absorbed slowly, counteracting the rapid surface run-off from concrete and tarmac that contributes to flooding. Development largely destroys the natural functions of soils through removal or sealing. Industrial contamination of soils constrains the reuse of some brownfield land.

## Development

Some 11 per cent of England and three per cent of Wales are covered with residential and industrial development and infrastructure[83]. Only about 10 per cent of urban areas is green space. Car parks and roads take around 40 per cent of developed areas. By 2016 another 1.3 per cent of England's soils could disappear under development, much of it to meet demand for an extra 3.8 million households (Figure 19).[84] Although there is a presumption against building on high-grade agricultural land and designated conservation sites, the value of other land for wildlife, archaeology, green space and flood control is not always given due weight.[24]

**Figure 19** Projected rates of change to urban land use in England, 1991 to 2016

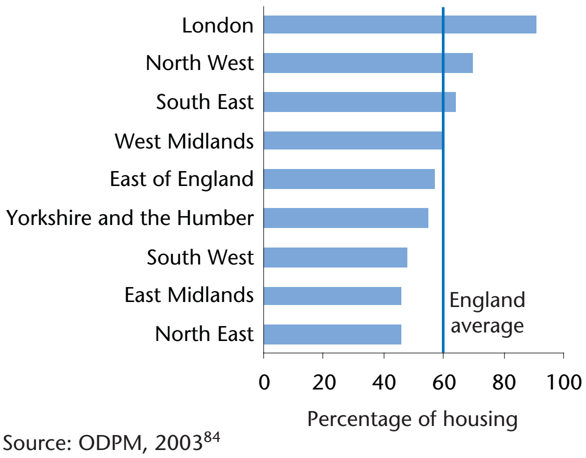



Source: Defra, 2003[83]

[1]The net percentage of a county projected to change from rural to urban uses.

Some brownfield land will be best retained for conservation and flood control, but focusing redevelopment on these sites can boost urban regeneration and protect greenfield land. Identifying the best use for land requires a case by case assessment to balance the socio-economic and environmental benefits. The Government's 2008 target for housing on previously developed land has already been met, but there is wide regional variation and more can be done (Figure 20).

**Figure 20** Housing built on previously developed land in England, 2001




Source: ODPM, 2003[84]

Planning is central to preserving the diversity of soils and the services they provide. Planners need access to better information on land and soil quality, and best practice for managing urban soils needs to be introduced. The Government's current planning system reforms are an opportunity to give appropriate weight to soil protection.

During construction soils are subject to movement, storage, compaction and contamination. The loss and damage to soils caused by development can be reduced by careful management of construction activities and by the reuse of soils in gardens and open spaces. Guidance on reusing and recycling soil is needed. The unauthorised disposal or inadequate containment of soil during construction can also cause problems. In 2002 in England and Wales there were 345 recorded water pollution incidents involving soil, of which 16 were serious (Environment Agency data).

## Flood risk

Soil can reduce the risk of flooding by slowing the passage of heavy rainfall to surface waters. Countries like Bangladesh and Pakistan provide extreme examples of how soil loss has increased lowland flooding. But there are also serious impacts in England and Wales. In October 1987, heavy rain swept more than 5,000 $m^3$ of soil from recently sown winter cereals on the South Downs, causing hundreds of thousands of pounds worth of damage to homes. Between 1976 and 2001 this area suffered 138 muddy floods from winter cereal fields.[13]

Cultivation practices for late-harvested crops, such as maize and potatoes, can cause severe soil degradation and may increase storm runoff by up to 20 per cent.[85] In the uplands, sheep grazing and trampling of the soil surface are associated with more rapid runoff to rivers like the Derwent and Lune.[82] While most soils, if undamaged, can accept heavy rain, bare and structurally degraded soils have less capacity to soak up rainfall. This leads to overland flow, water-driven soil erosion and flooding. Work is underway to improve understanding of these effects and to incorporate them into catchment flood management plans.[86]

"Some seven per cent of built-up areas in England and Wales are at risk from flooding."

In urban areas, soils are compacted by frequent use and sealed by hard surfaces, causing rain to run off rapidly and greatly increasing the risk of flooding. Planning Policy Guidance on new development in flood plains has been strengthened, although an appropriate flood risk assessment is still often not being submitted by developers. Local planning authorities decided against Environment Agency objections on 243 out of 1,088 cases in 2002/03.

Sustainable drainage systems, such as porous road surfaces, swales and wetlands, can reduce flood risk by storing rainfall and allowing it to percolate through the soil. They can also improve water quality by allowing the soil to filter and break down pollutants.[87] However, uptake of these systems has been slow, due to a lack of awareness and the absence of clear arrangements to install and maintain them.

## Soil contamination

More toxic pollutants, including heavy metals, PCBs, dioxins and PAHs, are found in urban than rural soils.[28] This is due to the proximity of industrial processes, waste facilities and heavy road traffic, although metal contamination from natural geological sources is also widespread. Metals and persistent organic substances can remain bound in soils for many years, where they can potentially contaminate plants and water or be transported on wind-blown soil particles.

As most people live in urban areas and some grow their own vegetables, soils need to be protected from industrial and transport pollution in cities, although most emissions have been greatly reduced over the past decade or so. Further assessment is required of historical contaminant levels in urban soils and of any consequent risks to human health.

The level of soil contamination is highly variable. The worst sites are designated by local authorities as contaminated land (land that poses unacceptable risks to public health or the environment). Such land must be made safe for its current use (under Part IIA of the Environmental Protection Act 1990), or for its proposed use if it is to be redeveloped (usually through planning conditions). Most local authorities now have a contaminated land strategy and should finish inspecting their areas between 2003 and 2006 (Box 5). By mid-2003, 63 sites had been confirmed as formally contaminated, of which 16 are 'special' sites where the Environment Agency becomes the enforcing authority. Thousands more sites have been identified as potentially contaminated and up to 20,000 contaminated sites in England and Wales may need treatment.[88] The legal complexities and costs of dealing with contaminated land can cause developers to choose greenfield rather than brownfield sites. This creates a double impact on soils in the form of the contamination (real or perceived) and the loss of greenfield soils.

**Box 5. Case study: Portsmouth City Council tackling contaminated land[89]**

Since 1991, Portsmouth City Council has investigated 243 sites covering 591 ha. Of these, it is reported to date that 49 sites, totalling 98 ha or 2.3 per cent of the council area, have been or are being treated. About 10 sites are being treated under the Environmental Protection Act 1990 but most treatment is voluntary, through the planning process. The council's inspection programme is expected to identify many more sites that will require investigation and possible action.

Tackling the legacy of contaminated land is a slow and complex task, but new contamination must also be avoided. In 2002 there were 24 recorded pollution incidents in England and Wales that resulted in contaminated soil, but there are likely to be many chemical spillages to soil that go unreported (Environment Agency data). Specific regulations apply to the disposal of certain hazardous substances to land to prevent entry into groundwater, and to the storage of oil. The new Pollution Prevention and Control regime, being rolled out to about 5,000 sites by 2007, tightens controls because when an installation closes, it requires operators to return the site to the condition it was in when the permit was issued. But awareness and good housekeeping to protect soils are often lacking, especially among small to medium-size enterprises. Leaky fuel and chemical storage tanks are still a common source of soil and groundwater pollution.

*Oil drums contaminating soil and groundwater*

7

# Cultural heritage

## Key points

- Soils preserve an irreplaceable archaeological and environmental heritage.
- Modern soil cultivation techniques are damaging many archaeological sites of national importance. Urgent action is required to minimise further losses.

The soils of England and Wales preserve an archaeological heritage that is one of the largest, most diverse and well documented in Europe. It is central to our culture and landscape. Archaeological remains are irreplaceable, yet they are being steadily destroyed by development and agriculture, and by natural forces such as wind and water. Peatlands and other soils also contain historical records of past vegetation, land uses and climate.

### Archaeological remains

The conversion of grassland to arable land exposes historic artefacts, field systems, burial mounds and other remains to the plough. Modern cultivation techniques are a significant cause of damage to these hidden remains.

In England:

- 23,500 ancient monuments have been destroyed since the middle of the last century – 10 per cent of the destruction and 30 per cent of the damage are attributable to agriculture;
- nearly 3,000 scheduled archaeological remains are being actively ploughed;
- in all, approximately one-third of all recorded archaeological sites are in ploughed land and two per cent are at high risk.[90, 91]

In Wales, there are 3,400 ancient monuments scheduled as nationally important, of which 2,630 were surveyed between 1985 and 1996. Some 15 per cent had suffered deterioration due to natural decay, agriculture and other causes.[92]

The surest way of reducing damage from cultivation is to turn the land back to grassland, but farming requirements often prevent this. The farming practices adopted need to be sensitive to the archaeological and other features of each site. The Environmental Impact Assessment Regulations (2001 in England, 2002 in Wales) for uncultivated land and semi-natural areas include protection for archaeological remains from intensive agricultural activity. Existing agri-environment schemes (Tir Gofal) include options to protect archaeological remains, for example through reduced grazing levels or conversion to grassland. Defra has proposed greater emphasis on the conservation of the historic environment in agri-environment schemes.[91]

The Forestry Commission records all known historic features on its land. Management plans are drawn up for all scheduled ancient monuments and there are guidelines for managing archaeological features.[93]

Archaeological remains may be affected by soil contamination or may themselves be a source of contamination. This may cause problems for the treatment of contaminated land. The Environment Agency and English Heritage are preparing guidance on how to manage the risks.

# References


1 Blum, WEH, 1993. *Soil Protection Concept of the Council of Europe and Integrated Soil Research*. In Soil and Environment Vol 1, eds.HJP Eijsackers and T Hamers, *Integrated Soil and Sediment Research: a basis for proper production*, pp37-47, Kluwer Academic Publisher, Dordrecht.

2 Department for Environment, Food and Rural Affairs, 2002. *Survey of public attitudes to quality of life and to the environment: 2001*. www.defra.gov.uk/environment/statistics/pubatt/content.htm

3 Hillel, D 1991. *Out of The Earth: Civilization and the Life of the Soil*. University of California Press.

4 United Nations Environment Programme, 2002. *Global Environment Outlook 3*. UNEP, EarthScan Publications, London.

5 European Commission, 2002. *Towards a thematic strategy for soil protection*. COM(2002) 179 final, Commission of the European Communities, Brussels.

6 Royal Commission on Environmental Pollution 1996. *Sustainable use of soil*. Nineteenth report, Cm 3165, HMSO, London, 260pp.

7 Soil Survey and Land Research Centre, 2000. *Soil protection in the UK*. SSLRC, Cranfield University, 5pp.

8 Milan, DJ, Petts, GE and Sambrook, H, 2000. Regional variations in the sediment structure of trout streams in southern England: benchmark data for siltation assessment and restoration. *Aquatic Conservation: Marine and Freshwater Ecosystems* 10, 407-420.

9 Walling, DE, Collins, AI, and McMellin G, 2001. *The provenance of interstitial sediment retrieved from salmonid spawning gravels in England and Wales: A reconnaissance survey based on the fingerprinting approach*. R&D Technical Report W2-046/TR3, Environment Agency, Bristol.

10 Hudson-Edwards, KA, Macklin, MG and Taylor, MP, 1999. 2000 years of sediment-borne heavy metal storage in the Yorkshire Ouse basin, NE England, UK. *Hydrological Processes*, 13, 1087-1102.

11 Coutadeur, C, Coquet, Y and Roger-Estrade, J, 2002. Variation of hydraulic conductivity in a tilled soil. *European Journal of Soil Science*, 53, 619-628

12 Department for Environment, Food and Rural Affairs, 2002. *Agriculture and water: a diffuse pollution review*. Defra, London, 115pp.

13 Boardman, J, 2003. Soil erosion and flooding on the eastern South Downs, southern England, 1976-2001. *Transactions of the Institute of British Geographers*, 28, 176-196.

14 McHugh, M, Wood, G, Walling, D, Morgan, R, Zhang, Y, Anthony, S and Hutchins, M, 2002. *Prediction of sediment delivery to watercourses from land. Phase II*. R&D Technical Report No P2-209, Environment Agency, Bristol, 95pp.

15 Johnes, PJ, Curtis, C, Moss, B, Whitehead, P, Bennion, H and Patrick, S, 2000. *Trial classification of lake water quality in England and Wales: a proposed approach*. R&D technical report E53, Environment Agency, Bristol.

16 Environment Agency, 1999. *Aquatic eutrophication in England and Wales: a proposed management strategy*. Environment Agency, Bristol.

17 Department for Environment, Food and Rural Affairs, 2003. *Strategic review of diffuse water pollution from agriculture*. Discussion document. Defra, London, 85pp.

18 Environment Agency, 2003. *River quality*. www.environment-agency.gov.uk

19 Department for Environment, Food and Rural Affairs, Environment Agency and English Nature, 2003 (unpublished data). *Development of a risk assessment and decision-making tool to control diffuse loads of phosphorus and particulates from agricultural land.*

20 Environment Agency, 2003. *Best Farming Practices*. www.environment-agency.gov.uk

21 Department for Environment, Food and Rural Affairs and the Welsh Assembly Government, 2002. *Second Consultation Paper on the Implementation of the EC Water Framework Directive* (2000/60/EC). Defra, London, 104pp.

22 Westcountry Rivers Trust, 2003. *Cornwall Rivers Project*. www.cornwallriversproject.org.uk

23 Agricultural Development and Advisory Service (ADAS), 2003. *Development of economically and environmentally sustainable methods of carbon sequestration in agricultural soils*. Research report to Defra, ADAS, Boxworth, 25pp.

24 Department of the Environment, Transport and the Regions (DETR), Scottish Executive, National Assembly for Wales and the Department of the Environment (Northern Ireland), 2000. *Climate change: draft UK programme*. DETR, London, 212pp.

25 Ministry of Agriculture, Fisheries and Food, 2000. *Climate change and agriculture in the United Kingdom*. Maff, London, 62pp.

26 Stevens, PA, Reynolds, B, Emmett, BA, Thompson, TRE, Loveland, PS, Jarvis, SC, Haygarth, P, Thomas, HR, Owen, DH, Roberts, R and Marsden, T, 2003. *Critical appraisal of state and pressures and controls on the sustainable use of soils in Wales*. Report by the Centre of Ecology and Hydrology, Bangor, to the National Assembly for Wales and Environment Agency.

27 Freeman, C, Evans, CD, Monteith, DT, Reynolds, B and Fenner, N, 2001. Export of organic carbon from peat soils. *Nature* 412, 785.

28 Hulme, M, Jenkins, GL, Lu, X, Turnpenny, JR, Mitchell, TD, Jones, RG, Lowe, J, Murphy, JM, Hassell, D, Boorman, P, McDonald, R and Hill, S 2002. *Climate change scenarios for the United Kingdom: the UKCIP02 Scientific Report*. Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, 120pp.

29 Ministry of Agriculture, Fisheries and Food (MAFF), 1998. *The vulnerability of soils to pollution by heavy metals*. Final report to MAFF, contract OC 9325, The University of Reading, ADAS, WRc.

30 Environment Agency, 2000. *The state of the environment of England and Wales: the land*. The Stationery Office, London, 181pp.

31 Spurgeon, DJ, Hopkin, SP and Jones, DT 1994. Effects of cadmium, copper, lead and zinc on growth, reproduction and survival of the earthworm *Eisenia fetida* (Savigny): assessing the environmental impact of point-source metal contamination in terrestrial ecosystems. *Environmental Pollution* 84, 123-130.

32 Her Majesty's Inspectorate of Pollution (HMIP), 1995. *Determination of polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in UK soils*. 2nd Technical Report. HMIP, London, 74pp.

33 Joint Nature Conservation Committee, 2003. *UK biodiversity website*. www.ukbap.org.uk

34 Black, HIJ, Hornung, M, Bruneau, PMC, Gordon, JE, Hopkins, JJ, Weighell, AJ and Williams, DL, 2003. *Soil Biodiversity Indicators for Agricultural Land: Nature Conservation Perspectives*. Centre for Ecology and Hydrology, Merlewood, paper to the OECD Expert Meeting on Soil Erosion and Soil Biodiversity Indicators, Rome, 25 to 28 March 2003.

35 Black, HIJ, Parekh, NR, Chaplow, JS, Monson, F, Watkins, J, Creamer, R, Potter, ED, Poskitt, JM, Rowland, P, Ainsworth, G and Hornung, M, 2003. *Assessing soil biodiversity across Great Britain: national trends in the occurrence of heterotrophic bacteria and invertebrates in soil*. Journal of Environmental Management 67, 255-266.

36 Environment Agency, 2002. *Persistent pesticides in soils: do registration procedures protect soil micro-organisms*. Environment Agency R&D report p5-053/P1, Bristol, 28pp.

37 Central Science Laboratory, 2003. *New Zealand Flatworm*. csl.gov.uk

38 Bunce RGH, Smart SM, van de Poll, HM, Watkins, JW and Scott, WA, 1999. *Measuring change in British vegetation. ECOFACT Volume 2*. ITE Monks Wood, 144pp.

39 Countryside Agency and Scottish Natural Heritage, 2002. *Landscape character assessment. Guidance for England and Scotland*. Countryside Agency, www.countryside.gov.uk, 84pp.

40 Haines-Young, RH *et al.*, 2000. *Accounting for nature: assessing habitats in the UK countryside*. Centre for Ecology and Hydrology and DETR, London, 134pp.

41 Fuller, RM, 1987. The changing extent and conservation interest of lowland grasslands in England and Wales: a review of grassland surveys 1930-1984. *Biological Conservation*, 40, 281-300.

42 Farrell, L., 1993. *Lowland heathland: the extent of habitat change*. English Nature Science No. 1, Peterborough.

43 English Nature, 2002. SSSI statistics. www.english-nature.org.uk/special/sssi/default.htm

44 Hall, J, Ullyett, J, Heywood, E, Broughton, R and Fawehinmi, J, 2003. *Preliminary assessment of critical load exceedance*. UK National Focal Centre, Centre for Ecology and Hydrology, Monks Wood.

45 National Expert Group on Transboundary Air Pollution, 2001. *Transboundary Air Pollution: acidification, eutrophication and ground-level ozone in the UK*. Centre for Ecology and Hydrology and Defra, London, 314pp.

46 Department for Environment, Food and Rural Affairs, Scottish Executive Environment and Rural Affairs Department, Department of Agriculture and Rural Development (Northern Ireland), National Assembly for Wales Agriculture and Rural Affairs Department, 2003. *Agriculture in the UK, 2002*. The Stationery Office, London.

47 National Assembly for Wales, 2003. *Key environment statistics for Wales, 2003*. National Assembly for Wales, Cardiff, 24pp.

48 Royal Society for the Protection of Birds, 2003. PROBE - profit without wildlife loss. www.rspb.org.uk/countryside/farming/working/probe/index.asp

49 Department for Environment, Food and Rural Affairs, 2002. *The strategy for sustainable farming and food*. Defra, London, 52pp.

50 Government of the National Assembly for Wales, 2002. *Farming for the Future*. The Government of the National Assembly for Wales, Cardiff, 54pp.

51 Department for Environment, Food and Rural Affairs, 2003. *The June agricultural census*. www.defra.gov.uk/esg/work_htm/publications/cs/farmstats_web/

52 National Assembly for Wales, 2003. *Survey of agricultural and horticultural census*. www.wales.gov.uk/keypubstatisticsforwalesheadline/content/agriculture/2003/headline-agriculture.htm

53 Ministry of Agriculture, Fisheries and Food, 1999. *Agricultural holdings in England and Wales, 1945-1998*. (Pers. comm. from K Stark.).

54 Westmacott, R, and Worthington, T, 1984. *Agricultural landscapes: a second look*. Prepared for the Countryside Commission. CCP 168. Countryside Commission, Cheltenham, 80pp.

55 Little, W (Ed), 1998. *Environmental effects of agriculture*. Final report. Prepared by ADAS for the Department of the Environment, Transport and the Regions. DETR, London, 167pp.

56 Fertiliser Manufacturers Association, 2003. *The Fertilizer Review 2002*. FMA, Peterborough.

57 Edwards, AC and Withers, PJA, 1998. Soil phosphorus management and water quality: A UK perspective. *Soil Use and Management*, 14, 124-130.

58 European Commission, 2003. *Extended Impact Assessment. Proposal for a regulation of the European Parliament and of the Council relating to cadmium in fertilisers*. Draft no.22 of 31.07.03, DG Enterprise, Brussels, 21pp.

59 Pesticides in the Environment Working Group, 2000. *Monitoring of pesticides in the environment*. Environment Agency, Bristol, 70pp.

60 English Nature, 2001. *State of nature - the upland challenge*. English Nature, Peterborough, 98pp.

61 Forestry Commission, 1998. *A New Focus for England's Woodlands. England Forestry Strategy*. The Forestry Commission, Cambridge, 36pp.

62 National Assembly for Wales, 2001. *Woodlands for Wales*. National Assembly for Wales, Cardiff, 49pp.

63 Bird, SC, Emmett, BA, Sinclair, FL, Stevens, PA, Reynolds, B, Nicholson, S and Jones, T, 2003. *Pontbren: effects of tree planting on agricultural soils and their functions*. Contract science report no.550, Countryside Council for Wales, Bangor.

64 Forestry Commission, 1998. *Forests and Soil Conservation Guidelines*. Forestry Commission, Edinburgh.

66 Chambers, BJ, Smith, KA and Pain, BF, 2000. *Strategies to encourage better use of nitrogen in animal manures*. Soil Use and Management, 16, 157-161.

67 Agricultural Development and Advisory Service (ADAS), 2003. *The Safe Sludge Matrix*. www.adas.co.uk/home/matrix.html

68 Ministry of Agriculture, Fisheries and Food, 2000. *Towards sustainable agriculture: a pilot set of indicators*. Maff, London, 72pp.

69 Loveland, PJ and Thompson, TRE (eds) 2002. *Identification and development of a set of national indicators for soil quality*. R&D Technical report P5-053/2/TR, Environment Agency Bristol, 41pp.

70 Skinner, RJ, Church, BM and Kershaw, CD, 1992. Recent trends in soil pH and nutrient status in England and Wales. *Soil Use and Management*, 8, 16-20.

71 Food Standards Agency, 2003. *Dioxins and dioxin-like PCBs in the UK diet: 2001 total diet study samples*. Food Standards Agency, London, 30pp

72 Office for National Statistics, 2003. *Environmental accounts: material flows 1970 - 2001*. www.statistics.gov.uk

73 British Geological Survey, 2003. *United Kingdom Minerals Yearbook 2002*. British Geological Survey, Keyworth, Nottingham.

74 Ministry of Agriculture, Fisheries and Food, 2000. *Good practice guide for handling soils.* www.defra.gov.uk/environ/landuse/soilguid/index.htm

75 Environment Agency, 2002. *Metal mine strategy for Wales*. Environment Agency, Cardiff, 26pp.

76 Reeve, MJ, Heaven, FW, Duncan, NA, 2000. *Evaluation of mineral sites restored to agriculture.* Report for MAFF, Land Research Associates, Derby.

77 Department of the Environment, Transport and the Regions, 1999. *Monitoring and assessment of products for growing media and soil improvers in the UK, 1999*. DETR, London.

78 Peat Producers Association, 2003. www.peatproducers.co.uk

79 English Nature, 1997. *Lowland peatland*. Position statement, English Nature, Peterborough, 1p.

80 Boorman, DD, Hollis, JM and Lilly, A, 1995. *Hydrology of soil types: a hydrologically based classification of the soils in the United Kingdom.* Report no.126, Institute of Hydrology, Wallingford.

81 Forestry Commission, 2000. *Forests & Water Guidelines*. Forestry Commission, Edinburgh, 36pp.

82 Johns, M, 1998. *The impact of grazing and upland management on erosion and runoff*. R&D Technical Report P123, Environment Agency, Bristol, 51pp.

83 Department for Environment, Food and Rural Affairs, 2003. *E-digest of environmental statistics.* www.defra.gov.uk/environment/statistics/index.htm

84 Office of the Deputy Prime Minister, 2003. *Land use change in England*: No 18A. www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_024948.pdf

85 Environment Agency, 2001. *Impact of Agricultural Soil Conditions on floods – Autumn 2000*. Environment Agency R&D Project W5C (00) 04, by Soil Survey and Land Research Centre, Cranfield University, Bristol.

86 Department for Environment, Food and Rural Affairs, Environment Agency, English Nature and Forestry Commission, 2003. *Wetlands, Land Use Change and Flood Management*. Defra, defra.gov.uk/environ/fcd/policy/wetlands/default.htm, 23pp.

87 Scottish Environment Protection Agency and Environment Agency, 1999. *Sustainable urban drainage, an introduction*. Environment Agency, Bristol, 21pp.

88 Environment Agency, 2002. *Dealing with contaminated land in England*. Environment Agency, Bristol, 40pp.

89 Portsmouth City Council, 2003. *Personal communication.*

90 English Heritage, 1995. MARS, *The Monuments at Risk Survey of England 1995*. www.english-heritage.gov.uk

91 English Heritage, 2003. *Ripping up History, Archaeology under the Plough*. English Heritage, Swindon, 4pp.

92 Ancient Monuments Board for Wales, 2002. *Annual report 2001-2002*. National Assembly for Wales, Cardiff.

93 Forestry Commission, 1995. *Forests and Archaeology Guidelines*. Forestry Commission, Edinburgh.

# CONTACTS:


### ENVIRONMENT AGENCY HEAD OFFICE

Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol BS32 4UD
Tel: 01454 624 400  Fax: 01454 624 409

**www.environment-agency.gov.uk**
**www.environment-agency.wales.gov.uk**


### ENVIRONMENT AGENCY REGIONAL OFFICES

**ANGLIAN**
Kingfisher House
Goldhay Way
Orton Goldhay
Peterborough PE2 5ZR
Tel: 01733 371 811
Fax: 01733 231 840

**MIDLANDS**
Sapphire East
550 Streetsbrook Road
Solihull B91 1QT
Tel: 0121 711 2324
Fax: 0121 711 5824

**NORTH EAST**
Rivers House
21 Park Square South
Leeds LS1 2QG
Tel: 0113 244 0191
Fax: 0113 246 1889

**NORTH WEST**
PO Box 12
Richard Fairclough House
Knutsford Road
Warrington WA4 1HG
Tel: 01925 653 999
Fax: 01925 415 961

**SOUTHERN**
Guildbourne House
Chatsworth Road
Worthing
West Sussex BN11 1LD
Tel: 01903 832 000
Fax: 01903 821 832

**SOUTH WEST**
Manley House
Kestrel Way
Exeter EX2 7LQ
Tel: 01392 444 000
Fax: 01392 444 238

**THAMES**
Kings Meadow House
Kings Meadow Road
Reading RG1 8DQ
Tel: 0118 953 5000
Fax: 0118 950 0388

**WALES**
Cambria House
29 Newport Road
Cardiff CF24 0TP
Tel: 029 2077 0088
Fax: 029 2079 8555


ENVIRONMENT AGENCY
GENERAL ENQUIRY LINE
**0845 9 333 111**

ENVIRONMENT AGENCY
F L O O D L I N E
**0845 988 1188**

ENVIRONMENT AGENCY
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