The state of the environment: soil

June 2019

Chair's foreword

Soil holds 3 times as much carbon as the atmosphere, it reduces the risk of flooding by absorbing water, it is a wildlife habitat, and it delivers 95% of global food supplies. Unfortunately, it is a limited resource under pressure from climate change, population growth, urban development, waste, pollution, and the demand for more (and cheaper) food.

This report aims to widen understanding about the state of soils. Leonardo Da Vinci said “we know more about the movement of celestial bodies than about the soil underfoot” and 500 years later, there is less information about soil than any other part of the environment.

Defra Secretary of State, Michael Gove, said: “Countries can withstand coups d’état, wars and conflict, even leaving the EU, but no country can withstand the loss of its soil and fertility”. We welcome the government’s work to move this up the political agenda both domestically and internationally. For example, the Department for International Development’s work helping farmers around the world adapt to climate change.

UK soil contains about 10 billion tonnes of carbon, roughly equal to 80 years of annual greenhouse gas emissions. Intensive agriculture has caused arable soils to lose 40 to 60% of their organic carbon, and the impacts of climate change pose further risks. Extended periods of wet weather can cause widespread damage to soil structure. Very heavy rainfall and thunderstorms cause soil erosion which exacerbates flood risks.

Soil carbon loss is an act of economic and environmental self-harm. If we are serious about the Committee on Climate Change’s target of net zero by 2050, then we need investment, regulation, better management of our bogs and peatlands, and collaboration with, and between, farmers.

Farmers manage 70% of the land. Poor soil quality affects their income and way of life. We work closely with farmers, providing advice, guidance and practical support. In Cumbria’s Eden catchment we are supporting a peer group learning about best practice. “Upstream Thinking”, funded by South West Water, is a good example of collaborative working to improve drinking water quality.

The new Farming Rules for Water will help. At present, there is low awareness about the new rules, so we are taking an advice led approach to help farmers meet the requirements. However, we will not hesitate to take enforcement action for pollution incidents where people are not acting in good faith.

We are also working on farm assurance schemes with WRAP, the National Farmers' Union, and the Renewable Energy Association, to address both the plastic waste produced by agriculture, and to reduce plastic contamination in bio-waste spread on farmland.

If badly managed, landspreading can damage soil health, contaminate crops and livestock, and it can affect the aquatic environment and bathing waters. We will continue to work with water companies and the waste sector to manage this risk.

Emma Howard, Chair of the Environment Agency

Key findings

- Soil is an important natural capital resource, providing many essential services.
- There is insufficient data on the health of our soils and investment is needed in soil monitoring.
- Soil degradation was calculated in 2010 to cost £1.2 billion every year.
- Almost 4 million hectares of soil are at risk of compaction in England and Wales, affecting soil fertility and our water resources, and increasing the risk of flooding.
- Over 2 million hectares of soil are at risk of erosion in England and Wales.
- Soil biodiversity and the many biological processes and soil functions that it supports are thought to be under threat.
- Wasting food and growing crops for bioenergy are putting additional pressure on soils.
- UK soils currently store about 10 billion tonnes of carbon, roughly equal to 80 years of annual UK greenhouse gas emissions.
- Intensive agriculture has caused arable soils to lose about 40 to 60% of their organic carbon.
- Spreading of some materials can give rise to contamination. Some 300,000 hectares are contaminated in the UK.
- Microplastics are widespread in soil with unknown consequences.
- Reversing soil degradation and restoring fertility by 2030 is an aim of the government's 25 Year Environment Plan.
- The proposed Environmental Land Management scheme provides an opportunity to reward farmers for protecting and regenerating soils.

Contents

Why soil is important

Government policy after the Second World War supported a significant increase in land used for agricultural production, converting permanent grasslands into tilled farmland. This has created a legacy of ever increasing intensification of farmland and degradation of soil. Pursuing agricultural production in the short term can result in soil degradation that limits the ability of soil to perform other functions. Some parts of the country such as fenland peats could be only 30 to 60 years away from the fundamental eradication of soil fertility.[1,2] However, the sustainable management of agricultural soils, including maintaining or enhancing the levels of soil organic carbon levels can provide multiple benefits.[3]

Soil is an important natural capital resource, providing many essential services, as highlighted recently by the Natural Capital Committee.[4] These include:

- supplying a suitable environment and conditions to grow food
- reducing the risk of flooding by absorbing water
- filtering water
- absorbing and reducing pollutants
- regulating our climate and gases in the atmosphere
- providing habitat for soil dwelling organisms and their associated services such as pest control and pollination
- protecting cultural heritage
- providing a stable platform for buildings
- providing raw materials
- the potential for new life saving medicines[5]

Maintaining healthy soils is important for food security, with 55% of the food consumed in the UK being produced here.[6] Some 95% of global food supplies are directly or indirectly produced on soil.[7] Around 129,000 hectares of agricultural land were used to grow crops for bioenergy in the UK in 2017, just over 2% of all arable land in the UK.[8]

Soil holds 3 times as much carbon as the atmosphere. UK soils currently store about 10 billion tonnes of carbon, roughly equal to 80 years of current annual UK greenhouse gas emissions.[9] However, degradation has led to most arable soils having already lost 40 to 60% of their organic carbon.[10,11]

In 2010, soil degradation in England and Wales was estimated to cost £1.2 billion a year.[12] Improved farming practices and land use are needed to rebuild the soil's carbon stores and prevent the generation of greenhouse gases from soil. This will be crucial in England's attempt to limit the effects of climate change.

Lack of evidence

It is widely accepted that more data on the health of our soils is needed.[13] This is essential to develop effective policies and programmes to protect this fundamental resource. Use of technology such as drones, satellite imagery and DNA sequencing alongside traditional field-based monitoring make it now possible to gather information on soil health without incurring excessive cost.

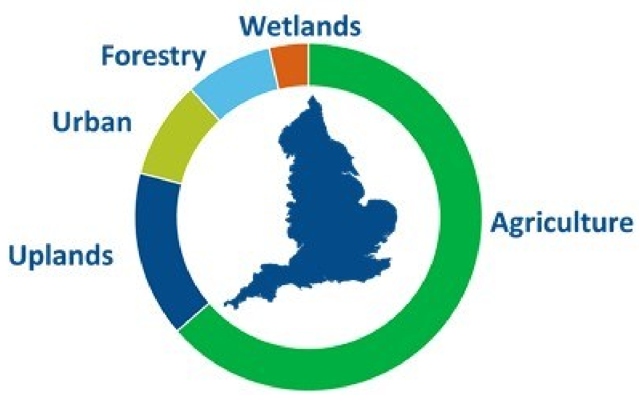
The most recent national data sets were collected as part of the Countryside Survey in 2007, 1998 and 1978, and the National Soil Inventory, which took samples in the 1990s and 1980s. The numbers of samples in these national studies have been small compared to the sampling intensity achieved for air and water quality monitoring.

Data on soil health are held piecemeal by different institutions and businesses. It is not easy to access or use these data. Local studies have been carried out and a network of long-term monitoring sites has recently been established for 37 nature reserves.[14]

Soil types and use

England has many different types of soil due to variations in geology, climate, plant and animal ecology and land use. 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. Most soils perform several functions.

Figure 1 Land use in England



England has a land area of 13,031,001 hectares,[15] of which about 70% is used for farming[16] - mainly arable, horticultural and improved grassland. About 11% of land is classed as urban development and 10% is forested (figure 1).[17]

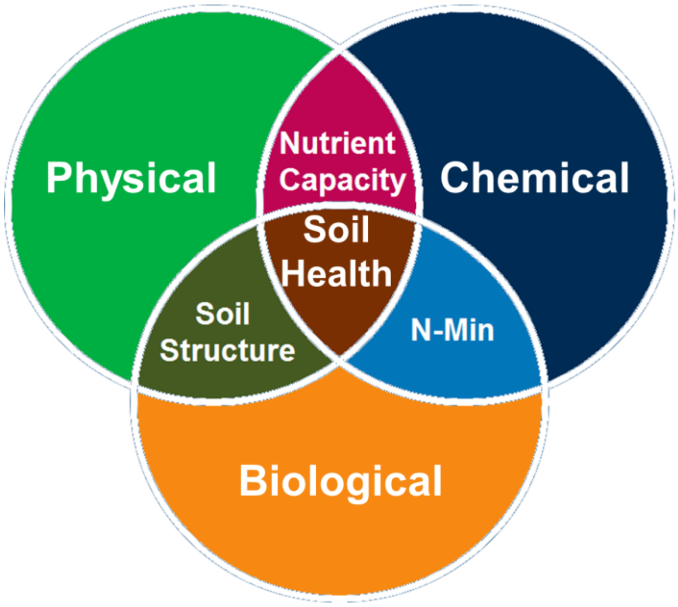
The way land is used for farming corresponds to the soil type and climate. Arable farming dominates in eastern England and other regions where soil fertility is high. The uplands of the north and west of England are characterised by poorer quality soils and, consequently, livestock farming predominates.

State and trends

Soil health

Soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans. Soil health depends on a range of physical, biological and chemical factors (figure 2). Important components include nutrients and acidity, organic carbon content, structure and water capacity, biological activities and chemical pollution. Soils are highly variable and so any assessment of soil health has to be designed accordingly. For instance, a healthy upland peat has very different properties to a healthy arable soil.

Figure 2 Components of soil health



Physical factors

Soil compaction

The structural health of soils is compromised by compaction.[18] Compaction is predominantly an issue on agricultural land, although forested areas and urban and amenity sites can also be affected. Changes to management techniques such as the use of heavier machinery[19] and extended grazing seasons have led to increased soil compaction.

When soils become compacted, they are more likely to become waterlogged and experience surface ponding that leads to run-off and flooding. This increases nutrient losses to watercourses causing pollution and reducing nutrient levels in soil. As a result, twice the amount of nitrogen fertiliser is needed to maintain yields.[20]

Land used to grow root crops, maize or winter cereals often has the most severe soil degradation. The occurrence of highly or severely degraded soil is about 15% higher for potatoes and maize than for land used to grow winter cereals.[21]

Severe soil compaction and poor soil condition is also an issue for around 10% to 15% of grassland fields, as a result of over-grazing.[22]

Construction sites using heavy machinery can cause the subsoil to be compacted - simply adding back the topsoil that was removed will not restore the soil and its functions.[23]

An estimated 3.9 million hectares of agricultural land are at risk of compaction in England and Wales, this risk is highest on clay soils during wet periods. The estimated total cost of compaction is £472 million per year (figure 3), nearly 3 times greater than that of erosion, reflecting its greater presence in the landscape.[12]

Soil structure in south-west England

A study of soil structure in the south-west found that enhanced surface water run-off across whole fields, caused by high or severe levels of soil structural degradation, was occurring at 38% of sites. A further 50% of sites had moderate levels of degradation with localised areas of run-off. Only 10% of sites featured low levels of soil degradation.

*Source: Palmer and Smith (2013). Soil structural degradation in SW England and its impact on surface-water runoff generation. doi.org/10.1111/sum.12068

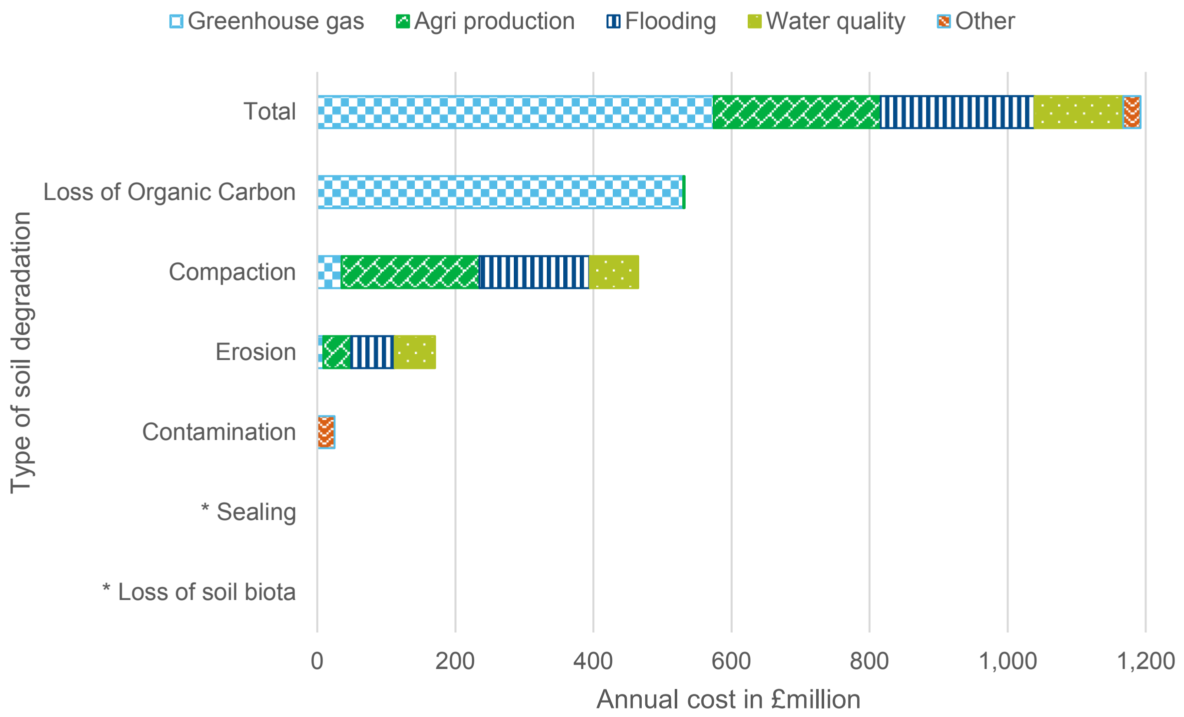
Soil erosion

Soil erosion and formation are natural processes. As long as erosion does not exceed the rate of formation then the soil will not be lost to future generations. The rate of new soil formation is slow at about 1 tonne per hectare per year. Erosion is regularly exceeding the rate of formation in many areas.[21] About 17% of arable soils in England and Wales show signs of erosion, although 40% are thought to be at risk.[12] Erosion is mainly confined to lighter arable soils on hillslopes and peats in upland areas.[12]

Of the 3 identified types of soil erosion (water, wind and removal during harvest) in England and Wales, erosion by water is the most extensive. A bare slope can be eroded up to 1,000 times faster than one covered in vegetation.[24] In the uplands, overgrazing by sheep and footpath use expose the soil and are believed to cause 75% of the erosion.[25]

Agricultural intensification has led to an increase in erosion. As fields have been increasing in size, the length of hedgerows has been decreasing. This makes the soil more susceptible to wind and water erosion. Every year England and Wales loses 2.9 million tonnes of topsoil to erosion. The total annual cost of erosion in England and Wales is about £177 million a year (figure 3).[12]

Figure 3 Cost of different types of soil degradation and what they impact[12]



* Unknown cost due to insufficient data

Land use change is an important factor in soil erosion risk. Significant decreases in erosion risk occurred when fields changed from winter cereal use to permanent grass.[26] Similarly, simple changes to management practices can make a big difference. For instance, integrating trees into arable crops using shelterbelts and along the field boundaries has been shown to increase crop yields and potentially reduce soil erosion by nearly two-thirds.[27, 28] The risk of soil erosion can be significantly affected by tillage practices,[29] with 80% of surface run-off in fields caused by poor tractor tramline practices.[30]

Wider impacts of erosion include: [31]

- siltation of rivers affecting fish spawning grounds
- flooding of properties and roads
- negative effects on water quality

Every year about 40 million tonnes of dredged material is disposed of at sea, some of which is eroded soil.[32]

In 2016, 58.7 million tonnes of soil was removed in urban areas, making up 26% of all waste generated in the UK.[33] Some soil will be recycled and used for landscaping, but soils remain one of the largest components of landfills with over 28 million tonnes sent in 2016.[33] This was 55% of the tonnage received.[33]

Soil sealing

Soil sealing is the covering of the ground by an impermeable material, such as the construction of roads or buildings, which stops it providing beneficial services.[34] Over 22,000 hectares of the UK's land surface was changed from farmland, forests or wetlands to urban development in just 6 years up to 2012. Soil sealing is under-reported, with areas sealed off for car parks and public spaces not included in the statistics.[35]

The use of undeveloped land for building in England has more than tripled from an average of 4,500 hectares a year in the 2000s to an average of 15,800 hectares between 2013 and 2017.[36] At current rates, over 1% of England's land will be converted to built development each decade.[37] Much of this land has been converted from crop production.[35]

The proportion of urban front gardens in England that are paved over jumped from 28% in 2001 to 48% in 2011. Between 2009 and 2013 an area of 5,500 hectares was covered with block paving,[38] sealing off the soil.

Biological factors

Organic matter

Soil organic matter is an important indicator of soil health and is crucial for long-term yields, food quality and extreme weather resilience, and as a vital store of soil carbon. Organic matter acts like a sponge and can hold up to 20 times its weight in water. It makes soil more resistant to drought and erosion.[39]

Over half of the soil carbon in England is contained within the top 30cm of the soil.[13]

Ploughing up permanent pasture for arable crops or temporary grassland usually reduces soil organic matter.[40] Most arable soils have already lost about 40 to 60% of their organic carbon.[10,11]

Around 11% of England is peatland.[41] These areas are very rich in carbon. Out of the 1.4 million hectares of peatland in England, less than 1% remains undamaged.[42] Peat soils are in serious decline, with only around 16% of the peat stock recorded in 1850 remaining.[43]

Peat in the UK is removed at up to 100 times faster than it can form.[44] As a consequence, shallow peat soils may disappear entirely within 15 to 40 years.[35]

The Great Fen project

It is possible to restore areas of peat, as demonstrated by the Great Fen project which is aiming to restore 3,700 hectares of fenland in Cambridgeshire.

The project is working in partnership with the local community, Wildlife Trusts, local authority, Natural England and the Environment Agency. Currently half of the required land has been purchased and over 866 hectares are being actively restored. This has already resulted in the spread of rare species of plants and birds.

Restoring the peat will bring different economic opportunities to the area. Instead of tilling the soil to grow crops, farmers will be able to raise sheep and cattle on the land. They will also be able to crop the reeds and reduce the phosphate and nitrate pollution.

The expansion of the fen will also provide greater flood protection for the surrounding communities and businesses.

*Source: www.greatfen.org.uk/about/history- project/restoration-wildlife

Drying peat out leads to decomposition of organic matter and shrinking. This reduces the ability of the soil to absorb water. It also lowers land levels and increases flood risk.[42]

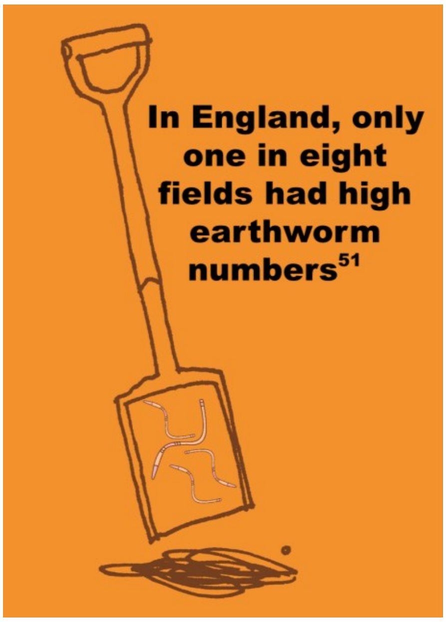
Soil biology

Soil contains an abundance of life - in just a gram of soil there can be as many as a billion bacteria.[13] This works out to about 5 tonnes of soil organisms per hectare, or the equivalent of 100 sheep.[45] Plant roots work with microorganisms to extract nutrients bound up in soils and fix nitrogen from the air.[35] There are around 11 million species of soil organisms, but fewer than 2% have been named and classified.[46]

The soil invertebrate community has only been surveyed nationally twice (in 1998 and 2007). This highlights the evidence gap for one of the major indicators of soil health. Although it is not possible to draw long-term trends from the results, they do highlight the significantly fewer invertebrates in arable habitats than other habitats.[47]

Intensive agriculture uses practices such as monocultures and tilling. These reduce the soil biodiversity, making food webs less diverse with fewer functional groups, and having an impact on the soil's ability to provide ecosystem services.[48,49,50]

Soil organisms such as earthworms play an important part in maintaining the structure and functioning of soils. The casts of earthworms act as channels allowing water and air to penetrate the ground. Earthworms also help to incorporate organic matter from the surface into the soil and redistribute nutrients. Results from a recent on-farm earthworm survey showed that most fields have some earthworms present, but 42% of fields may be overworked, as indicated by an absence or rarity of earthworms. Tillage had a negative impact on earthworm populations, and organic matter management did not mitigate tillage impacts.[51] Earthworms are also adversely affected by the use of chemicals and increasingly by invasive species. For example, the introduction of the New Zealand flatworm may reduce earthworm biomass by 20%.[52]



A mycorrhiza is the symbiotic association of plant roots with soil fungi, and are found in 80% of plant species. This association forms a vast network within the soil and enhances the functioning of the soil in terms of both fertility and water cycling. Intensively tilled and highly fertilised arable soils have reduced mycorrhizal fungal diversity and greatly reduced fungal biomass. In forests with excessive nutrients the normal mycorrhizal fungi are outcompeted by those that are more tolerant of pollution. These complex ecosystem changes can negatively affect tree health.[53]

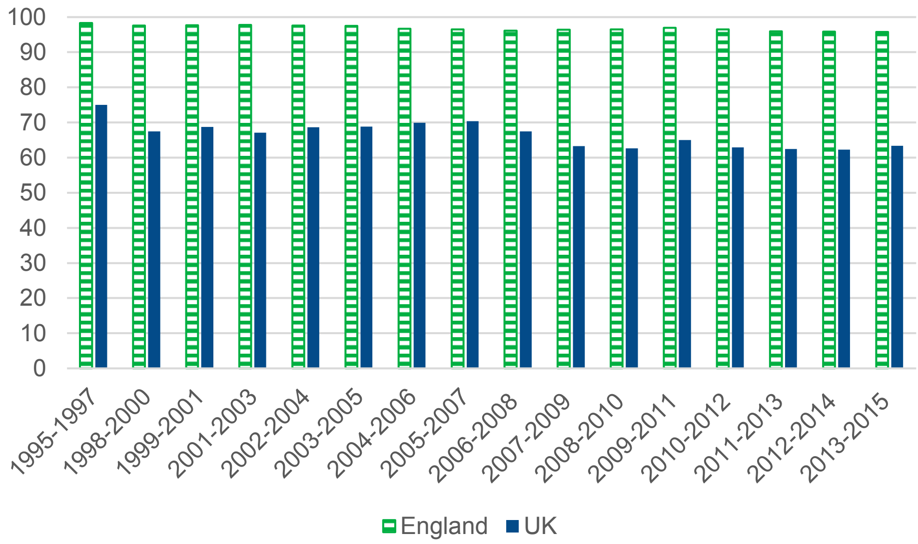
Chemical factors

Nutrients

A fertile soil contains a balanced supply of nutrients for a growing crop. Nutrients that are removed in harvested crops have to be replaced or the soil becomes less fertile and unproductive. Some nutrients are replenished by recycling manures, where available, or by growing crops such as nitrogen fixing legumes; otherwise mineral fertilisers have to be used to maintain fertility. Good management of soil nutrients depends on regular soil sampling and analysis. Nutrient management planning allows land managers to match inputs of nutrients to crop demand. This optimises the yield, minimises nutrient use and costs and minimises losses to the environment. Modern crop varieties have been bred to maximise yield, not to achieve optimal nutrient use efficiency.[54]

Almost all sensitive habitats are exceeding critical loads (figure 4). Atmospheric nitrogen deposition is having a negative effect on various sensitive habitats. It is reducing species richness on both acidic and calcareous grasslands, as well as increasing carbon loss from peat bogs.[21] About 15% of woodland soil in England and Wales is nitrogen saturated.[55] This can also increase aluminium toxicity to the plant roots.[55]

Figure 4 Percentage of nitrogen-sensitive habitat areas where nutrient nitrogen critical loads are exceeded[56]



Acidification

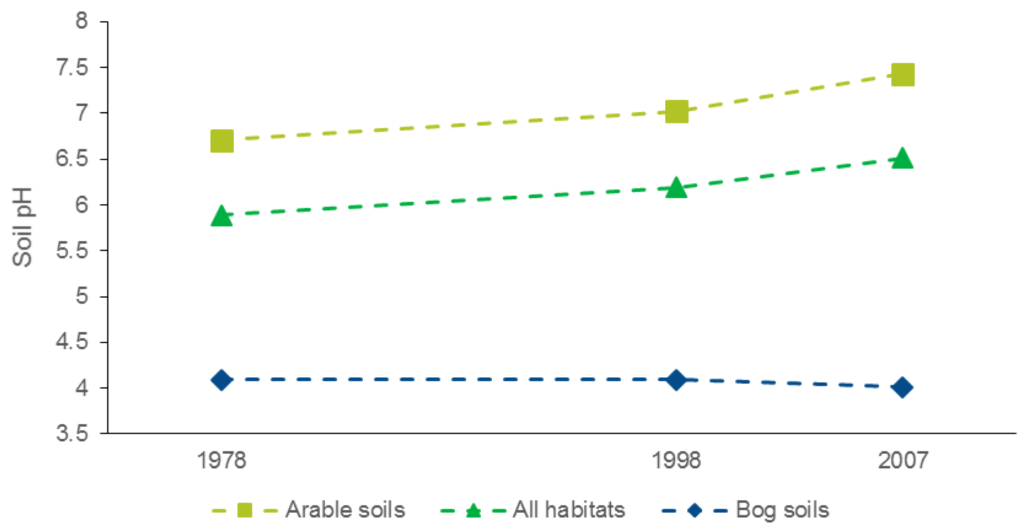
Soil pH affects the availability of nutrients in the soil. Increasing acidity mobilises heavy metals and toxins, negatively affecting both plant and animal communities.

Atmospheric pollutants such as sulphur dioxide, ammonia and oxides of nitrogen (NOx) create acidic compounds which are deposited onto the soil and decrease its pH.[57] The main sources of these pollutants are:

- power stations
- transport
- household heating
- agriculture
- industrial processes

In the past, industry emitted high levels of atmospheric pollutants which resulted in increased soil acidity. Recent changes to the fuels used in power stations, vehicles being fitted with catalytic converters, and industrial processes becoming cleaner has resulted in significant reductions in air pollution and soils have started to recover.

Figure 5 Changes in the average pH of soils (0 to 15cm) from sampling plots in all habitats in England between 1978 and 2007[47]



Soils in England became less acidic between 1978 and 1998 (figure 5). This trend continued to 2007 for less acidic soils but not for more acidic ones. The reductions occurred because of decreases in industrial emissions and subsequent deposition of sulphur. The difference between soil types reflects geographical variation in deposition levels and different sensitivities of soil types.

Contamination

Land used for industry, such as to store and dispose of waste and chemicals, has caused contamination of soils. Unintentional contamination has also occurred through accidents, spills and the demolition of buildings that contained toxic substances. Contaminated land needs to be remediated before it can be used for urban development.

Land used for agriculture is also at risk of contamination. Heavy metals and other contaminants are deposited via atmospheric deposition, livestock manures and the spreading of wastes and sewage sludge.[58] The most recent estimate of the total area of contaminated land in England, from 2005, is 300,000 hectares.[59]

Some 80% of treated sewage sludge in the UK is applied to agricultural soil to improve organic matter and nutrient levels.[60] However, the sludge can contain materials such as metals, microplastics, persistent organic pollutants and pharmaceuticals which contaminate the soil.

Several studies have shown that pharmaceuticals applied to the soil via treated sewage sludge accumulate in crops, re-entering the food chain.[61,62] Although the concentrations consumed are unlikely to cause a health risk, the risk from long-term consumption are not fully known.[63]

The application of sewage sludge as a fertiliser has been identified as an important source of microplastics.[64] Studies have shown that composts made from household waste also usually contain plastic. In addition, plastic mulches and fleeces used in horticulture have been found to fragment into microplastics[65] and accumulate in soil where they adsorb agrochemicals.[66] Many plastics are treated with chemicals such as flame retardants, which then contaminate the soil.[64]

The impacts of plastic accumulating in the soil are not well understood. There is already evidence indicating that microplastics interact with soil organisms,[67] reducing their ability to provide important ecosystem services. Further research is required into the unknown affects of microplastics entering the food chain and being consumed by people.[64]

Current and future pressures

Agriculture

Agriculture can be damaging to soils if not managed properly. Agriculture is becoming more intensive, with bigger, heavier machinery used, fields increasing in size and greater focus on maximising yield.

Where land is harvested regularly, the carbon content in the soil will decline due to organic compounds being broken down, and being removed in crops or eroded.[59]

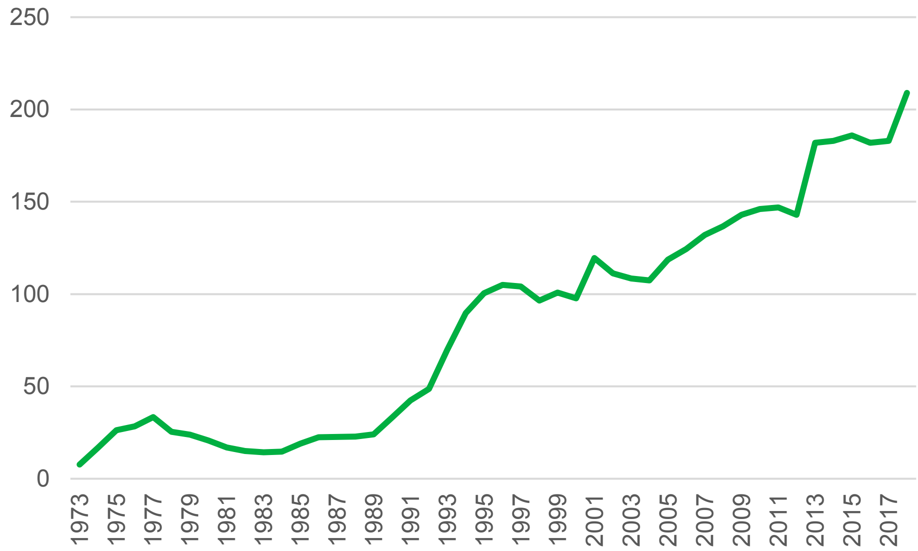
Changes to the types of crops grown can present a risk to soil health. For example, changes to subsidies have meant that farmers have been incentivised to grow maize for biofuel production. This has resulted in the area used to grow maize having tripled since the early 1990s (figure 6).[68] Maize fields are

LIDAR targeting soils at risk

Changing the crops grown on a field can alter the risk of erosion. This means that the locations of high risk sites change every year, making it difficult for preventative action to be taken. Advances in technology allow satellite imaging to be updated every couple of days, which can be combined with LIDAR data and soil maps to identify fields at high risk of erosion. This allows Environment Agency officers to contact the owners of these high risk sites and work with them to remediate the area.

*Source: Environment Agency, 2017. Using satellite imagery and mobile device technology to tackle diffuse pollution from agriculture subject to high rates of erosion because the crop has shallow roots that do not support the soil, and the crops are harvested late in the autumn. Where maize is grown, up to half of river sediment comes from the maize fields.[69]

Figure 6 Area of maize grown in England, 1973 to 2017 ('000 hectares)[70,71]



There have been significant reductions in area of orchards, natural grasslands and wetlands. These provide habitats for rare species but are now being converted to intensive farming as well as facing pressure from land development.[72]

Agricultural management practices can also improve soil. Soil organic matter can be increased through the use of minimum tillage, crop residues, grass and legume leys, manures, and modest additions of fertilisers. This also helps to remove some of the carbon from the atmosphere.[73]

Farming initiatives

Farmers and land managers can get advice and support on soil management from Natural England through Catchment Sensitive Farming (CSF) and the Countryside Stewardship scheme. The mitigation measures put in place through CSF have been shown to reduce loadings of nutrient, sediment and bacteria entering rivers from farms resulting in improvements to water quality.

The Farming Rules for Water, introduced in April 2018, require farmers to test their soils. They then need to plan and apply their fertiliser or manure to improve soil nutrient levels and meet crop needs. The rules include minimum storage and spreading distances from water bodies. They also require the farmer to assess weather and soil conditions to reduce the risk of run-off and soil erosion.

*Source: CSF Phase 4 evaluation report (in press)

Climate change

The climate is changing. The UK average temperature has increased by nearly 1ºC compared to the 1961-90 average. More rain is falling in intense storms, and sea level is rising. By the end of the century, summer temperatures could be 4ºC higher and sea level may rise by 1 metre or more.[74] There will be an increased threat of soil erosion and further loss of soil fertility, as well as a loss of high-quality agricultural land from sea level rise.

Soils store carbon that would otherwise end up in the atmosphere. Climate change is predicted to result in a significant loss to the amount of carbon stored in the soil due to changes in the vegetation cover, and there will be pressure to reverse the loss.[75, 76]

Changes to soil temperature and moisture levels will make farm planning difficult. There may be both opportunities and risks from farmers growing different crops. Increased tree planting, restoration of peatlands and changing farming practices can all improve soil and water quality.[77] This land-use reform can help mitigate the impact of climate change by storing more carbon, and also reduce the impacts of flooding and improve water quality.[77] Without action, soils will become increasingly less fertile, damaging wildlife and the ecosystem services that soils provide.

Population growth

Population increase and economic pressure are increasing the amount of agricultural and rural land being used for building. Once soil is lost, its ability to deliver its functions is very difficult to retrieve and, in the long-term, this could be catastrophic.

The rate of urbanisation has been continually increasing.[78] On average, 200,000 new homes are being built every year, but demand is still not being met and only about half are built on brownfield sites. The rest are sealing up soils, preventing them from accumulating organic matter and providing other important ecosystem services.

Increased or more intensively managed agricultural land area may be needed to feed a growing population. This need has been historically met through the conversion of grasslands to farmland.

As the population increases, more waste will be produced. This will increase the demand on soil to receive, store and potentially recycle waste materials. This needs to be achieved while minimising any adverse effects.[79]

Some types of waste are increasingly being spread to land. Although this can improve the health of soils, it is important to ensure that risks of contamination are minimised.

Emerging pollutants

About 16,600 tonnes of pesticides and herbicides were used on British farms in 2016.[80] Recently, new studies have shown that the weed killer glyphosate, which was thought to break down in the soil, can persist for longer than originally thought.[81] Glyphosate has also been shown to negatively affect soil organisms that are responsible for maintaining soil nutrients and structure. It is a possible carcinogen[82] and has been detected in human food.[83] New pesticides, developed to reduce the quantities used, can have negative effects on soil organisms. For example, clothianidin, a neonicotinoid which is now banned for outdoor use in the UK and other countries across Europe, is highly toxic to earthworms and persists for a long time in the soil.[84]

The overuse of antibiotics has led to an increase in antimicrobial resistance genes. These are accumulating in soils through the addition of manures and treated sewage sludge,[85] and can permanently alter the soil microbial community structure.[86] From there they are being dispersed to the wider environment,[87] raising concerns for healthcare as it will become harder to treat illnesses.

Nanoparticles are contaminating soils as a result of sewage sludge spread to land and via pesticide applications.[88, 89] Silver nanoparticles are being applied to soils via sewage sludge and have been shown to be toxic to plants, affecting their root production.[90] Biosolids containing nanomaterials can disrupt plants' uptake of nitrogen and can change the types of microorganisms found in the soil, negatively affecting rates of plant growth. They have also been shown to be toxic to bacterial communities.[91] This is a relatively new threat and more research is required to determine the extent of the problem.

Looking ahead

Soil has been overlooked in environmental policy in recent decades. However, the government's 25 Year Environment Plan states that England’s soils must be managed sustainably by 2030, and steps must be taken towards restoring the UK’s soils.

A new system of public money for public goods will reward farmers for environmental outcomes such as emphasising healthy soils. There is a huge opportunity for the new Environmental Land Management scheme to incentivise farmers by rewarding them for protecting and regenerating soils.

Monitoring and measuring the Earth's environment from space may provide opportunities to monitor soils remotely and supplement or replace traditional field monitoring. Crop data from the EU's Copernicus Sentinel satellites and other Earth observation data are being used with soil, elevation and other variables to develop a diffuse pollution risk assessment. This can be used to help target water quality monitoring at catchment and national scales.

England only produces about 55% of the food it consumes, relying on imports for the rest. Soil degradation is not just a national issue, and high levels of food consumption in wealthy countries such as England are also a major driver of soil degradation overseas.[92] Climate change is predicted to cause losses of soil organic carbon. The combination of these pressures causes concern for England's food security, and in conjunction with increasing land consumption for residential use, will place greater demand on agricultural soils.

Contamination of soils is often thought to be a thing of the past, but new and emerging chemicals and waste management practices bring new regulatory challenges and environmental risks. The first step towards understanding these risks and challenges will be to understand our soils and how they are changing.

[1] Speech by Michael Gove at Sustainable Soils Alliance's parliamentary reception held 25 October 2017. https://www.soilassociation.org/news/2017/october/25/secretary-of-state-commits-to-soil-health/ (viewed on 16 April 2019)

[2] Matysek, M. and others (2019). Impact of fertilizer, water table, and warming on CO2 and CH4 soil emissions and celery yield from fenland agricultural peat. Science of the Total Environment 667:179-190. https://www.sciencedirect.com/science/article/pii/S004896971930868X?via%3Dihub (viewed on 16 April 2019)

[3] Banwart, S.A. and others (2015). The global challenge for soil carbon, in Soil Carbon: Science, Management and Policy for Multiple Benefits (ed. S.A. Banwart, E. Noellemeyer and E. Milne). CABI International

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