A stylized illustration in the top left corner shows a sun with wavy rays and a field with curved lines representing furrows or grass.

Soil provides the foundation for life in terrestrial ecosystems and is a repository of biodiversity. Healthy soil gives us food, fibre and timber, and helps ensure clean water and air, and diverse wildlife and landscapes. The interdependency of soil, water and air needs to be recognised in an integrated approach to environmental protection.

Soil is constantly changing and evolving, and while some degradation processes are natural, human activity can accelerate these processes, and introduce others, and thereby impair the soil's capacity to carry out the functions we require from it. What we want our soil to provide, how well it can do this, the potential threats both now and into the future, need to be known in order to protect and improve long-term agricultural and forestry productivity, as well as water and air quality. No comprehensive assessment has been undertaken of the extent or severity of threats to soil such as erosion by wind and water, surface sealing, loss of organic matter, contamination, landslides, loss of soil biodiversity, compaction and salinisation. Human activity can impair the soil's capacity to carry out its essential functions. The impact of climate change on soil functionality needs to be quantified and assessed.

Our knowledge and understanding of soil quality and functions is limited. To progress this we must improve the monitoring and mapping of soils, quantify and prioritise threats and develop a national framework for their management. In the long term we need to integrate soil protection measures and sustainable land management practices into national policies and strategies.

SOIL

12

## Introduction

The soil of Ireland is an immensely valuable, and finite, national resource, which forms and evolves slowly over very long periods of time. However, it can easily be damaged and lost. Soil is a biologically active, complex mixture of weathered minerals (sand, silt and clay), organic matter, organisms, air and water that provides the foundation for life in terrestrial ecosystems.



Healthy soil gives us food, fibre and timber, clean water and air, and diverse wildlife and landscapes. Soil achieves all this by performing six essential functions.

- Soil is the growing medium for food, forage crops, fibre, energy crops and timber. It stores nutrients

and water for crops and provides anchorage for root growth.

- Soil regulates and controls water flow over land and filters rainfall passing through the soil to plants and groundwater. Soil influences river flows and flooding.
- Soil filters and buffers potential pollutants. The microorganisms and minerals in soil filter, buffer, degrade, utilise, immobilise and detoxify large numbers of organic and inorganic materials, including slurries, industrial organic wastes and sewage sludge.
- Soil stores, transforms and cycles essential nutrients such as carbon, nitrogen, phosphorus, potassium and sulphur. Soil also takes up, stores and releases atmospheric gases.
- Soil provides raw materials and foundation support for buildings and protects our archaeological and cultural remains.

Soil is an important habitat and gene reserve for an enormous variety of soil organisms such as earthworms and microorganisms. The biological diversity below ground far exceeds that above it. It is this diversity that enables soils to perform the functions listed above, which support all life on earth (Blum, 1993; Environment Agency, 2004; United States Department of Agriculture – Natural Resources Conservation Service (<http://soils.usda.gov/sqi/concepts>)).

## The Current Situation: Our State of Knowledge of Soil and Soil Quality

### Soil Quality

How well soil does what we want it to do determines soil quality. Our maritime climate, predominance of permanent grassland, sustainable land management practices and lack of historic industrialisation have contributed to the maintenance and protection of soil quality across the country. The general consensus is that soil quality in Ireland is good; however, this is based on limited information and therefore the degree of certainty is low. The ultimate purpose of knowing and assessing soil quality and potential threats is not to achieve, for example, high soil aggregate stability, biological activity, or some other soil property; rather the purpose is to protect and improve long-term agricultural and forestry productivity, water and air quality, and the habitats of all living organisms and humans (USDA Natural Resources Conservation Services).

### Sources of Information on Soil

Information on soils can be broadly classified into three categories: soil maps, soil inventories and soil monitoring systems (Van-Camp *et al.*, 2004). In Ireland we have some soil maps and an inventory of soil

**Table 12.1 Summary of Mapped Information on Soil in Ireland (Source: Daly and Fealy, 2007)**

Map	Scale	Coverage	MMU <sup>1</sup>	Map unit type	Soil properties
An Foras Talúntais county maps (1959-1985)	1:127,560	44% of country	10	Soil series <sup>2</sup>	Yes (profile description and analysis)
General soil map (1980)	1:575,000	National	100	Soil associations <sup>3</sup>	Yes (great soil group level)
Teagasc/EPA indicative soil maps (2006)	1:150,000 (nominal)	National	0.02	Simple classification	No
National Soil Database (2007)	n/a	National – 2 samples /100 km <sup>2</sup>	n/a	n/a	Yes (chemical and biological)

<sup>1</sup>MMU, minimum mapping unit in ha; <sup>2</sup>soil series, soils with similar type and arrangement of horizons and developed from similar parent material; <sup>3</sup>soil associations, great soil groups occurring in repeatable patterns across landscape ( $n = 44$ ).

**Table 12.2** Soil Classification Scheme used in Ireland (Source: [www.teagasc.ie/johnstowncastle/soilsofireland](http://www.teagasc.ie/johnstowncastle/soilsofireland); Gardiner and Radford, 1980)

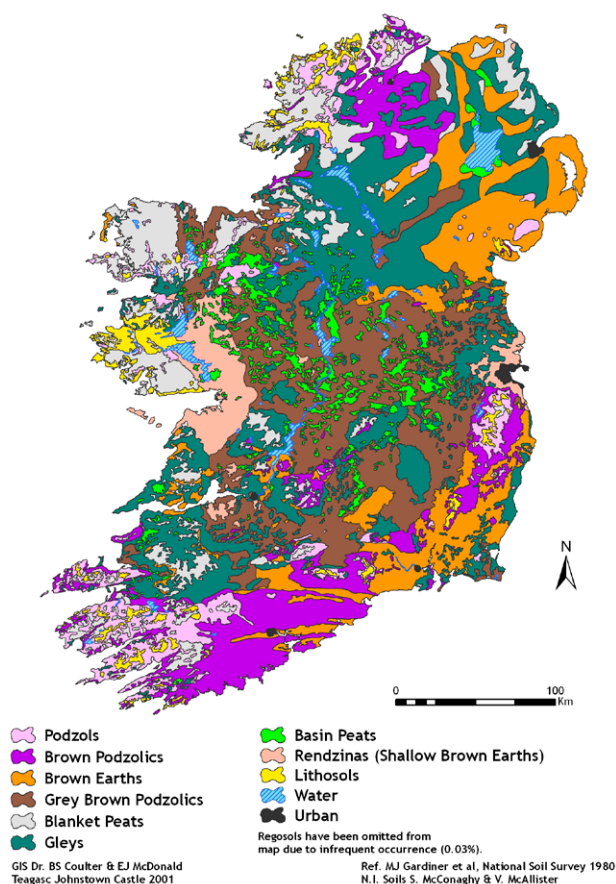
	Great Soil Group	Occurrence %	General Properties
1	Podzols	7.11	Formed by leaching of nutrients (podzolisation process), acidic and poorly drained
2	Brown Podzolics	11.71	Less depleted of nutrients than podzols, good physical characteristics
3	Grey Brown Podzolics	19.70	Usually formed from calcareous parent material which counteracts the effects of leaching, can be light to heavy textured
4	Brown Earths	13.60	Most occur on lime-deficient parent materials, therefore acidic in nature, relatively mature and well drained
5	Gleys	25.03	Developed under the influence of permanent or intermittent waterlogging, impervious with poor physical structure, unsuitable for cultivation or intensive grazing
6	Rendzinas (Shallow Brown Earths)	4.08	Shallow soils, usually no more than 50cm depth, usually derived from limestone parent material, use limited by shallow depth
7	Lithosols	3.01	Skeletal stony soils usually overlying solid or shattered bedrock, use limited to rough grazing and forestry
8	Regosols	0.03	Alluvial soils found in low lying flat areas along river course and estuaries, texture can vary between sands and clays, can be acid or alkaline depending on the material from which they are derived, wide range of uses
9	Basin Peats	5.03	High organic matter content (>30% down to at least 30cm depth), formed in depressions
10	Blanket Peats	10.70	High organic matter content (>30% down to at least 30cm depth), formed under conditions of high rainfall and humidity

geochemical properties. We do not have a national soil monitoring system. The recently published *Digital Soil Information System for Ireland – Scoping Study* report concluded that soil data coverage of Ireland is incomplete in both detail and extent (Daly and Fealy, 2007).

### The General Soil Map of Ireland

This map, derived from the General Soil Map of Ireland, based on work by An Foras Talúntais during the 1960s and 1970s, has been simplified to show great soil groups only. Great groups are amalgamations of soils that have broad similarities in their degree of development and properties, although each Great Soil Group contains soil 'types' that differ in detail from each other (Gardiner and Radford, 1980). There are 10 great soil groups in Ireland, as shown in Table 12.2 and illustrated in Map 12.1. The area covered by each soil group is also given.

**Map 12.1** Great Soil Groups of Ireland (Source: Teagasc, 2001)





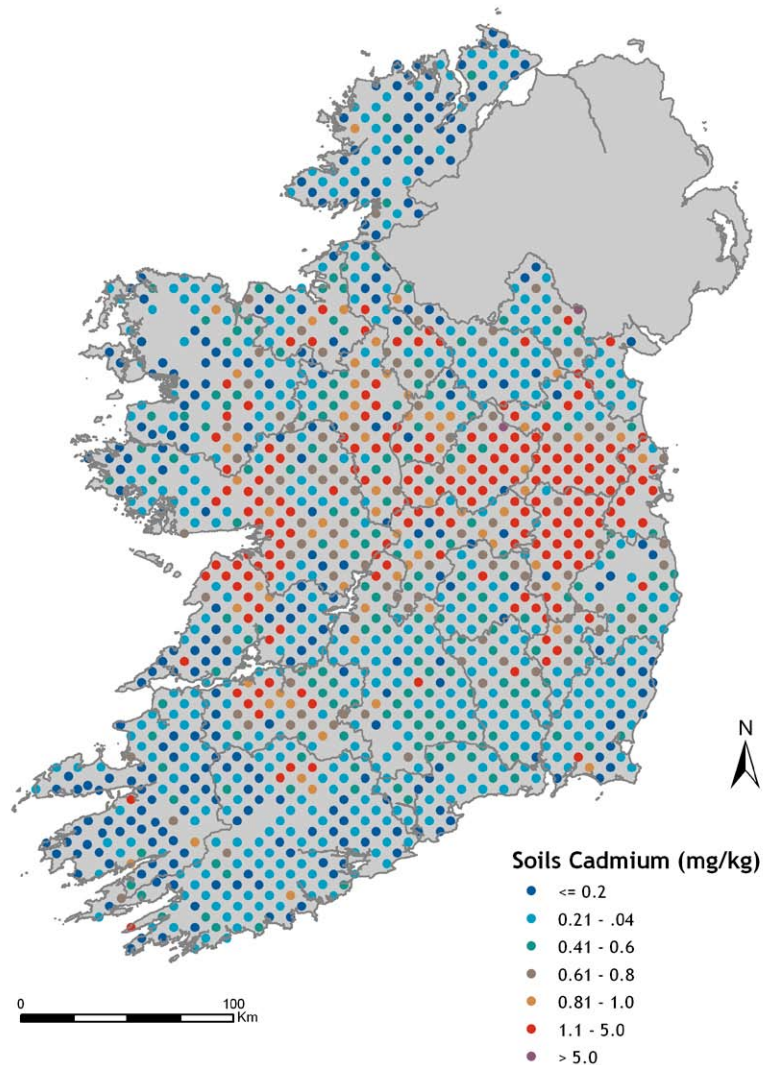
### National Soil Database

The National Soil Database (NSDB) has produced for the first time datapoint and spatial distribution maps for 45 elements, including major nutrients such as phosphorus, potassium and magnesium, essential trace elements such as cobalt, copper and selenium, and other elements of interest (due to their potential toxicity) such as cadmium, arsenic, lead, nickel and mercury. This provides Ireland with a robust and structured baseline of soil geochemical properties relevant to environmental, agricultural and public health related pressures, which can be used to assess trends in measured parameters over time and to quantify the soil's response to environmental pressures. The NSDB also performed large-scale microbiological analysis of soils and investigated microbial community structure in a range of soil types (Fay *et al.*, 2007a, 2007b).

The NSDB demonstrates that there is generally a strong, but varying, relationship between the geochemical results and soil type and the underlying geology. Other influences include oceanic deposition, proximity to urban areas, and mining and agriculture activities. The maps and analytical data can be utilised widely by all relevant stakeholders, including land managers and policy-makers, with the understanding that the maps are derived from approximately 1,300 soil samples taken on a 10 × 10 km grid to 10 cm depth. The maps can assist in:

- predicting areas where trace element deficiencies such as cobalt (Co) or copper (Cu) for grazing livestock may arise; for example, soils with Co concentration of less than 5 mg/kg, or where high soil magnesium concentration prevents uptake of cobalt by herbage

**Map 12.2** Datapoint Map for Concentration of Cadmium in Irish Soils (Source: National Soils Database)



Includes Ordnance Survey Ireland data reproduced under OSI License number EN 0059208.

- predicting areas where certain toxicities may arise; for example, selenium (Se) toxicity in grazing livestock occurs on soils with concentrations in the range of 10–50 mg/kg
- predicting areas where crop deficiencies of essential elements or soil acidification may occur, which may result in reduced crop yields
- predicting areas where sewage sludge cannot be applied because

the threshold limits for heavy metals (cadmium, copper, nickel, lead, zinc and mercury) in soils, as specified in the EU Sewage Sludge Directive (European Council, 1986) have already been reached

- the coordination and selection of appropriate sites to carry out further research and comparative studies into, for example, estimating soil organic carbon stocks on a national basis, soil biodiversity research.

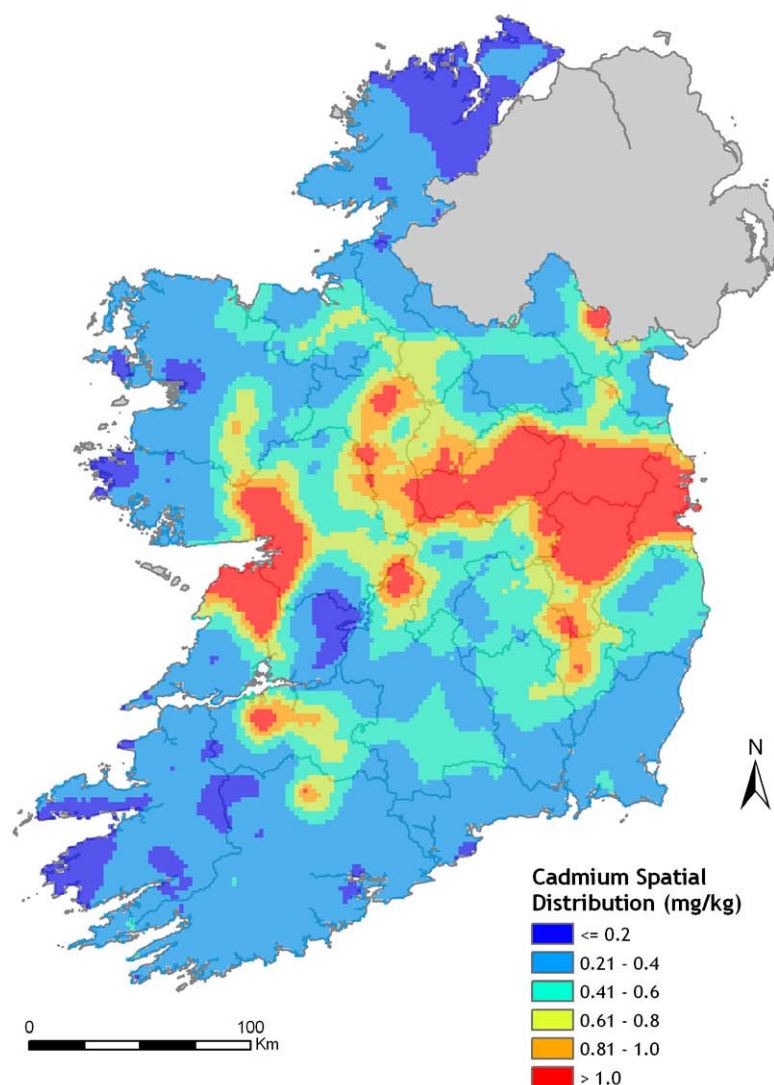
In relation to the application of sewage sludge to land, the study found, at a national level, that 15 per cent of the soils analysed exceeded the threshold value of 1 mg/kg for cadmium (Cd), while 23 per cent of the soils exceeded the threshold value of 30 mg/kg for nickel (Ni). Maps 12.2 and 12.3 are examples of the two types of map that have been produced, i.e. datapoint maps that show the sample location and actual concentration of the element at that location, and spatially interpolated distribution maps that use statistical techniques to estimate the likely concentration between all sample points for a given element.

The final report, including the analytical data and maps, is available through the EPA website: [www.epa.ie/nsdb](http://www.epa.ie/nsdb).

### Pressures Leading to Deterioration or Loss of Soil Functions

Soil is constantly changing and evolving, and while some degradation processes are natural, human activity can accelerate these processes, and introduce others, and thereby impair the soil's capacity to carry out the functions we require from it. Erosion by wind and water, surface sealing, loss of organic matter, contamination, landslides, loss of soil biodiversity, compaction and salinisation are soil threats that can lead to a reduction in soil functionality (Van-Camp *et al.*, 2004; Eckelmann *et al.*, 2006). Any assessment of soil threats and their impact on soil functions should be considered in terms of consequences and the extent, the reversibility and the level of uncertainty in our understanding of the issues (Towers *et al.*, 2006). It is likely that many of these soil threats are occurring in Ireland to a greater or lesser extent

**Map 12.3 Spatial Distribution Map for Cadmium in Irish Soils (Source: National Soils Database, 2007)**



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but no comprehensive assessment of their severity or extent has been made. The potentially significant impact of climate change on soil functionality needs to be quantified and assessed.

### Decline in Soil Organic Matter

Soil organic matter (SOM) is defined as the organic fraction of the soil exclusive of undecayed plant and animal residues (SOM = soil organic

carbon (SOC)  $\times$  1.72) (Gardiner and Radford, 1980). SOM plays a critical role in soil structure and soil aggregate stability, water dynamics (retention and filtering) and nutrient retention and recycling, and is the food source for soil organisms. It therefore has a key role in maintaining and improving soil quality and protecting water and air quality, as well as in the global carbon cycle, and loss of it results in increased carbon dioxide and, in some circumstances methane

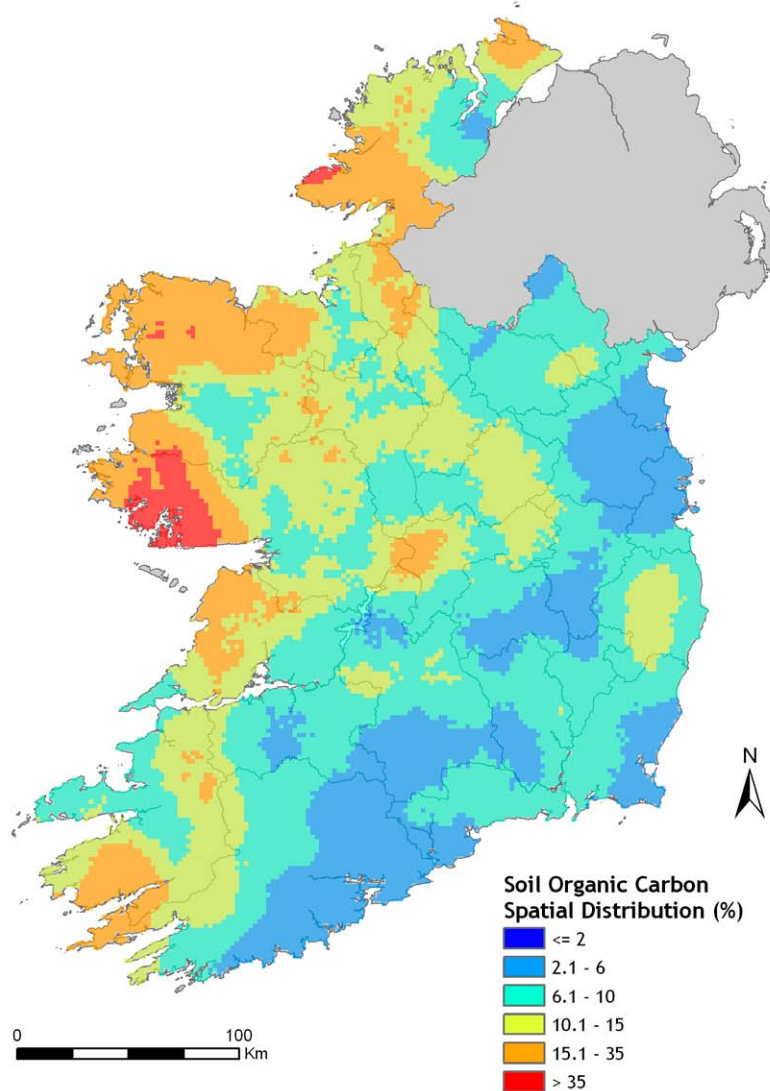
and nitrous oxide (both powerful greenhouse gases) emission to the atmosphere (Towers *et al.*, 2006). More than twice as much carbon is held in soils as in vegetation or the atmosphere, and changes in soil carbon content can have a large effect on the global carbon budget (Bajes, 1996; Bellamy *et al.*, 2003).

Ireland's soils are relatively rich in soil organic matter, especially our wetter soils and blanket and basin peats. The Irish SOC stock is estimated at 2.4 Petagrams (Pg), in comparison to the current global estimate SOC stock of 1500 to 1550 Pg (1 Pg =  $10^{15}$  g or  $10^9$  t) (Bajes, 1996; Lal, 2004; Post *et al.*, 2001; Schlesinger, 1995). Sixty-two per cent is held in our peat soils, with the remaining 38 per cent in all other soil types (Eaton *et al.*, 2007). This estimate is calculated to 1 m depth for mineral soils and to full depth for peats. Further information on SOC stocks and research in this area is available from <http://soilcarbon.ucc.ie>. The NSDB produced a map of SOC based on the 1,300 soil sample locations showing the percentage of SOC. Map 12.4 shows the spatial distribution map for SOC.

The map shows good correlation of SOC concentrations with the location of peat soils along the western seaboard, in the mountains and in the Midlands. Soils rich in organic carbon are particularly sensitive to changes in soil moisture and soil temperatures, therefore the potential impact of climate change on soil carbon stocks could be significant.

Peat extraction and land-use changes such as increased urbanisation or ploughing of rough or permanent grassland for tillage and energy crops will lead to increased SOM loss from soils. It is likely that increased soil temperatures as a result of global warming will increase biological

**Map 12.4 Spatial Distribution Map for Soil Organic Carbon**  
(Source: National Soils Database, 2007)



activity in the soil, resulting in losses of organic carbon, as carbon dioxide and methane, to the atmosphere.

### Soil Erosion by Wind and Water

Soil erosion is a process whereby soil is worn away by physical processes such as wind and flowing water, or other natural or anthropogenic agents that abrade, detach and remove soil from one point on the earth's surface to be deposited

elsewhere (Soil Science Society of America, [www.soils.org](http://www.soils.org)). Soil erosion also impacts on water courses, in which the eroded sediments can result in fish kills or eutrophication. Soil erosion occurs as a result of poor soil management practices on vulnerable soils including inappropriate cropping regimes, overgrazing, and direct access to watercourses. Forestry activities can also cause significant soil erosion. At the moment, serious incidents of soil erosion are localised but it is



likely that climate change will cause increased rates of soil erosion due to higher rainfall intensity and possible loss of organic matter, which will result in reduced structural stability.

### Surface Sealing

Soil is sealed when it is taken into the built environment as a result of development for housing, industry, transport and other physical infrastructure. By using soil as a physical support medium, clearly other soil functions are lost, e.g. food production; environmental interactions; and support for ecosystems, habitats and biodiversity. It is likely, given the location of our towns and urban areas on the flatter, more easily accessible lands, that our most versatile and good quality soils are being lost to urbanisation. There is also growing evidence that the urban sealing of soils leads to rapid and enhanced runoff during rainstorms and this in turn is a significant contributor to downstream urban and other forms of riverine flooding. There is no comprehensive information on the quantity and quality of soil being lost to surface sealing in Ireland on an annual basis or the consequences of this in terms of loss of soil functionality and increased flooding risks.

### Compaction

Soil compaction occurs where a heavy load is applied to the soil surface from machinery and livestock trafficking, particularly during unfavourable weather and soil conditions (Hamza and Anderson, 2005). Soil compaction reduces soil porosity and permeability, resulting in damage to or partial destruction of soil structure. Soil structure has a major influence on plant growth and regulation of water flow (and hence flood risk). Good structure enhances the cycling of nutrients

and air between the soil, plants and the atmosphere and is essential for the diversity and well-being of soil organisms. Soil low in organic matter is more vulnerable to soil compaction. No comprehensive data are available on the severity or extent of soil compaction in Ireland.

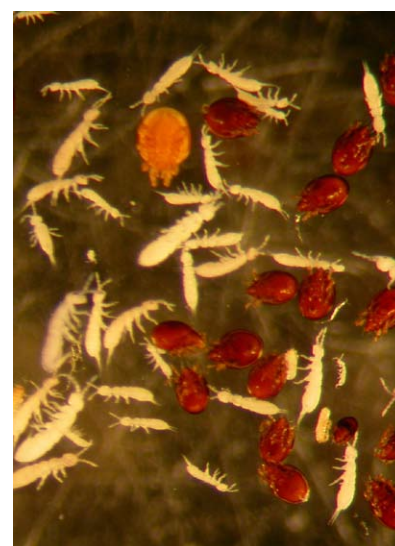
### Loss of Soil Biodiversity

Soil biodiversity is the mix of living organisms in the soil. It has been estimated that the top 30 cm of a hectare of soil contains up to 25t of soil organisms (Blum, 1988). These organisms interact with one another and with plants and small animals, forming a web of biological activity. Beetles, springtails, mites, worms, spiders, ants, nematodes, fungi, bacteria and other organisms are integral to the soil food web and contribute to soil being the most biologically active part of earth's ecosystems. These organisms improve the entry and storage of water, soil structure and resistance to soil erosion, plant nutrition and the breakdown of organic matter (<http://soils.usda.gov/sqi/assessment>). Invasive species such as the New Zealand flatworm (*Arthurdendyus triangulatus*), which is present in Irish soils, prey on certain species including earthworms. Studies in Scotland have found a 12 per cent reduction of earthworm populations in some field sites and changes in community structure have also been recorded (Towers *et al.*, 2006). The extent of spread on the New Zealand flatworm and the impact of this and other invasive species needs to be assessed.

While protecting soil biodiversity is very important, our understanding and knowledge of this largely unexplored ecosystem and the key links between biodiversity and soil function are limited (Towers *et al.*, 2006). While some information

is available on soil biodiversity in Ireland, e.g. NSDB and the CréBeo (living soil) project, there is no comprehensive national basis on which to assess it. Further information on some current research in this area can be found at [www.ucd.ie/crebeo](http://www.ucd.ie/crebeo).

**Figure 12.1** Springtails and Mites Extracted From Soil (Source: Dr Aidan Keith, UCD): Springtails (*Collembola*) are the most abundant insects in the world



### Soil Contamination

Soil can be contaminated by a wide range of potential pollutants, through either local (point source) contamination or diffuse contamination. Contamination from point sources can arise as a result of leakages and accidental spillages from commercial activities that use the soil for support or space, e.g. petroleum storage tanks, old gas work sites, tanneries, timber treatment or landfills. Diffuse contamination arises as a result of deposition from the atmosphere and activities such as agriculture, forestry, horticulture, landspreading of organic wastes, etc.



### Point Source Contamination

Contaminated sites include old landfills, abandoned mine sites and old industrial activities such as steel or gas works. The EPA has estimated the number of commercial sites where there is a potential for soil and/or groundwater contamination to be somewhere between 1,980 and 2,300 (Brogan *et al.*, 1999, Brogan *et al.*, 2002). The impact on soil function will depend on the substances present and the degree of contamination. Progress is being made in relation to the legacy of contaminated sites in Ireland, although it will take many years before all legacy issues are dealt with.

There is no national inventory of contaminated sites. However, there are currently two national initiatives in operation to establish inventories for historic mine sites and unregulated waste disposal sites (EPA, 2007). Apart from these, there is no national framework approach to the management of

contaminated sites in Ireland. Ireland lacks specific legislation for dealing with contaminated soil, and the application of existing legislation is often difficult, piecemeal and arbitrary (McIntyre, 2006). Unlike many of our European counterparts, Ireland has yet to develop environmental quality standards for soil to assist in delivering a consistent approach to the management of contaminated soils that is protective of human health and the wider environment.

### Diffuse Contamination

Landspreading of agricultural and industrial organic wastes exploits the soil's ecological capabilities to utilise, filter, adsorb, buffer and transform these wastes. Problems arise where the soil's assimilative and/or buffering capacity is exceeded and where the wastes contains potentially toxic contaminants. Certain wastes can have a direct toxic effect on soil organisms, thereby limiting the soil's ability to deal with these wastes.

Over 60 million tonnes of agricultural organic wastes (animal slurries and manures, dirty water and silage effluent) and 0.6 million tonnes of industrial organic wastes, including sewage sludge, are landspread annually (EPA, 2005, 2008). With proper management, these wastes recycle valuable nutrients to assist in crop productivity. However, with poor management, the application of these wastes in excess of crop requirements, or where the wastes contain toxic elements not required for plant growth, may result in soil degradation and water pollution.

The application of sewage sludge to land is one of the prime anthropogenic sources of heavy metal inputs into soil. A large collaborative UK research project, commenced in 1999, suggests that heavy metals from sewage sludge are damaging soil microbial populations (UK Water Industry Research Ltd, 2007). The findings indicate that, even working close to the statutory limits of the



EU Sewage Sludge Directive, sewage sludge application has a negative impact on soil microbial populations and soil functions. The heavy metal concentration of sewage sludge in Ireland is generally lower than that of the UK. However, the National Soil Database indicates that, at a national level, 15 per cent of soils exceed the threshold value of 1 mg/kg for cadmium, while 23 per cent exceed the threshold value for nickel.

Pesticide use in Ireland is regulated by the Pesticide Control Service (PCS) of the Department of Agriculture, Fisheries and Food. Given the soil's ability to filter, buffer, degrade, immobilise and detoxify pesticides and the limited land area devoted to tillage, where pesticide use is greatest, it is unlikely that pesticide usage represents a widespread threat to soil functionality. In relation to the disposal of spent sheep dip it would appear that organophosphorus compounds are readily broken down by soil organisms and synthetic pyrethroids appear to bind very tightly to soil particles. While it appears that the soil is capable of absorbing and breaking down these compounds, very little is known about their impact on soil functionality (Scottish Environmental Protection Agency, 2001).

Atmospheric deposition from industry, transport, households and agriculture contribute to soil acidification and eutrophication that can result in losses of nutrients to water courses, including groundwater. The principal precursors of acid rain are  $\text{SO}_2$  and  $\text{NO}_x$  from fossil fuel burning and  $\text{NH}_3$  from agriculture, which causes acidity in the soil following chemical transformations. The main sources of nitrogen deposition from the atmosphere to terrestrial ecosystems leading to eutrophication are

$\text{NO}_x$  from fossil fuel burning and  $\text{NH}_3$  from agricultural activities. Although terrestrial ecosystems may accumulate considerable amounts of nitrogen in biomass and soil organic matter, there is increasing concern that they may become overloaded. Nitrogen saturation can interfere with soil and water chemistry, plant species composition and greenhouse gas fluxes. To assess the likely impacts of atmospheric deposition, the critical load concept is used to determine the impact of anthropogenic pollutants on soil and water environments. The critical load concept concerns balancing the deposition that an ecosystem is exposed to with its capacity to buffer the input. A recent report by the Coordination Centre for Effects (CCE) for transboundary air pollution indicates that for Ireland under current legislative emissions, 10 per cent of the soils are at risk from exceedances of critical loads for acidification, which is predicted to decrease to 6 per cent by 2020. Deposition for acidity has a strong east–west gradient. Under current legislated emissions (relating to the Gothenburg Protocol), 35 per cent of the mapped soils (forests and semi-natural ecosystems) receive nitrogen deposition in excess of the critical load for nutrient nitrogen (based on the empirical model approach). This is predicted to decrease to 30 per cent by 2020. Exceedance of critical load for nutrient nitrogen may lead to changes in the composition of plant species (Slootweg *et al.*, 2007).

### Landslides

Landslides and floods are closely allied because both are related to heavy precipitation, slope runoff and the saturation of soil by water. Landslides occur as a result of a combination of factors relating to soil type and physical properties



(Source: Dr Olaf Schmidt, UCD)

such as slope gradient and profile, soil drainage and permeability, and land cover, triggering factors such as heavy rainfall and changes in land use and land cover, and human activities such as excavations, undercutting and land drainage (Geological Survey of Ireland, 2006).

The GSI Irish Landslides Working Group identified 117 landslide events in Ireland. Most of these (63) involved peat as the main material, while 31 were composed of coarse debris. Co. Wicklow has had the most events, followed by Co. Mayo and Co. Antrim. There are a few historic incidents of large landslides in Ireland where loss of life and/or serious damage occurred, e.g. Castlegrade, Co. Limerick in 1708 and Derrybrien, Co. Galway in 2003. More recent landslide events in Greevagh, Co. Sligo and at Lyreacrompane, near Listowel, Co. Kerry further demonstrate the impact that large landslides can have on the environment. These landslides have resulted in significant damage to the land affected, to nearby roads and bridges, to local streams, rivers and fish stocks and caused drinking water pollution and threatened reservoir supplies.



Criteria such as depth of peat and degree of slope were combined with available soil and subsoil information by the Landslides Working Group to predict susceptibility (GSI, 2006). The distribution of actual landslides appears to correlate well with predicted susceptibility maps. Further research is needed and other thematic and digital datasets must be added to improve the robustness of the susceptibility maps (GSI, 2006). While landslides are generally a local phenomenon and Ireland is not considered a high-risk area, the potential impact of climate change – increased intensity of rainfall and reduced soil structure stability – also needs to be considered and addressed.

### Our Response

Our knowledge and understanding of many issues relating to soil functions is limited, due to the lack of data on which to base this judgement. Soil

protection measures and sustainable land management practices should be integrated into national policies. In addition, many land-based activities, while not impacting directly on soil quality, have the potential to impact significantly on water or air quality – nutrient loss from soil to water, ammonia emission to the atmosphere, soil organic carbon losses, etc. Improving Ireland's water and air quality requires an understanding of the role of soil. The interdependency of soil, water and air needs to be recognised in an integrated approach to environmental protection. It is apparent that information and knowledge on soil in Ireland is incomplete, in both detail and extent.

There is little legislation relating directly to soil and soil protection. However, in 2006, the European Commission published the final Thematic Strategy for Soil Protection (COM(2006)231 final) and a proposal for a directive establishing a framework for the protection of soil

(COM(2006)232). The overall objective of the strategy is the protection and sustainable use of soil, based on the guiding principles of preserving soil functions, preventing further degradation and restoring degraded soils to a level of functionality consistent with current and intended use. The European Soil Thematic Strategy should guide and frame Ireland's approach to developing its own soil protection strategy.

A number of priority initiatives to protect soils and, in doing so, protect water and air quality include the following.

1. Soil data coverage of Ireland is incomplete and exists in many variable and disparate forms. Without a comprehensive national soil map produced to an appropriate scale and with all the associated soil physical and chemical data, tackling issues such as quantifying the extent of soil threats in Ireland, predicting runoff risk and nutrient loss for



(Source: GSI)

soil to water, managing SOC stocks, estimating soil carbon sequestration or release to the atmosphere, and understanding and reducing  $\text{NH}_3$  emission to atmosphere will be extremely difficult. As a starting point we need to know the soils we have and their chemical, physical and biological properties. A digital national soil map to 1:250,000, the target scale identified at European level, is required in addition to a soil information system that will provide a technical platform to organise, store and distribute soil information. A scoping study funded by the EPA outlines in detail the work and resources required to develop this national map (see [www.epa.ie](http://www.epa.ie) for more details). The delivery of this national map and its associated information is a priority. In June 2008 the EPA awarded research funding to Teagasc and protect partners Cranfield University, UK and University College Dublin to develop a soil map at 1:250,000 scale and associated Soil Information System (SIS). The project is expected to be completed in 2013.

2. A critical assessment of existing evidence about the state of Irish soils and the pressures that are currently affecting soil functions needs to be undertaken. The vulnerability of soil to these pressures needs to be assessed and understood. The extent of the soil threats in Ireland needs to be quantified and prioritised according to their potential to impact on soil, water and air. The potential impact of climate change and land-use change on the extent of soil threats needs to be evaluated as part of this critical assessment.
3. The requirement for a national soil quality-monitoring network

that would take account of our soils' spatial variability, different land use, and future risks needs to be evaluated. This work should be based on that outlined in 1 above. A set of relevant soil quality indicators and trigger thresholds upon which to measure changes in soil quality over time is an integral part of a national soil quality monitoring network.

4. A national framework plan for the management and remediation of contaminated soil in Ireland needs to be developed. Unlike some of our European counterparts, for example the UK and the Netherlands, Ireland lacks specific legislation for dealing with contaminated soil, and the application of existing legislation is often difficult and piecemeal. National legislation dealing specifically with soil contamination needs to be developed, including a mechanism for dealing with historical contamination. Soil guideline values for priority contaminants in soil need to be derived specifically for Ireland. These guideline values are a screening tool for use in the assessment of the risks posed to human health and/or the environment arising from exposure to contaminated soil.
5. The regulation of the application of sewage sludge to land needs to be revisited. Any review should take a more holistic approach involving the local authorities that are responsible for the generation and treatment of sewage sludge and those at farm level where sewage sludge is reused in agriculture. The regulation of sewage sludge in agriculture needs to include an overall management system that records and monitors the quantities produced, the type of

sludge and treatment undergone and application restrictions. At the farm level, a nutrient management plan for the landbank used for the application of sewage sludge is essential along with a structured monitoring programme of the sludge and the receiving soils. This management system should be dynamic and capable of adapting to any peer reviewed research emerging in this area. At a national level, consideration should be given to the use of Geographical Information Systems (GIS) to monitor the application of sewage sludge to soil.

## Conclusion

Our soil needs to be afforded the same protection as is given to air and water. We need to know the state of our soils, and the pressures placed on them, evaluate the extent of soil degradation and respond to degradation processes in an informed and structured manner. We need to plan for the protection of soils to ensure that they can continue to perform the functions we require of them and to protect against the real risk from climate change. We cannot protect this intrinsically valuable national resource without the appropriate and essential information and understanding. We cannot achieve good water or air quality without knowing our soils and how they behave in relation to pressures placed on them. Our soils are our life ... they are intrinsically connected to our water and air, and we must strive to protect them.

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[www.epa.ie/downloads/pubs/research/land](http://www.epa.ie/downloads/pubs/research/land)

<http://soils.usda.gov/sqi/concepts>

Soil Science Society of America web at [www.soils.org](http://www.soils.org)