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PROTECTING THE SOIL RESOURCE

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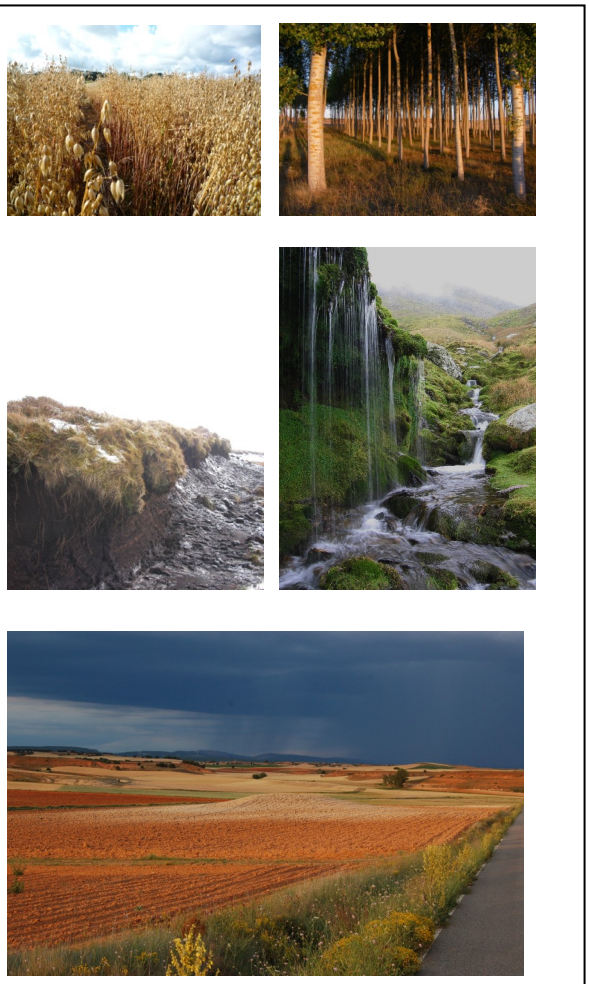
"A nation that destroys its soil destroys itself."

This quote from, F.D. Roosevelt, 1937, from a letter written to all state Governors in the USA following the dust bowl, encapsulates the importance of soil protection to a nation. The dust bowl brought about legislation to protect and conserve soils as a fundamental natural resource in the USA between 1930 and 1936. When most people think of soils, they'll likely think of gardening or farming, but supporting the provisioning of food, feed and fibre is only one of the functions that soils provide that are important for human wellbeing, and sustaining the functionality of the earth's life support system. Increasing global population creates an escalating demand for food, feed and fibre, the production of which relies heavily on the soil resource. Of the earth's terrestrial land surface, ~134 million km^2 (Mkm^2), arable agriculture is estimated to cover 15 Mkm^2, and managed grazing 28 Mkm^2.[i] We've now exploited all the easily cultivable land, so that creating more land for agriculture means cutting down forests, which is not a good option. Estimates for the next 50 years indicate that mankind is moving to a global density of 1 person for each 0.01 km^2 of reasonably biologically productive land.[ii] This increase in population pressure means that we must continue to extract more from our soils to support the growing demand if we want to protect the earth's forests. The mantra of our time appears to be, 'more for less'.



Soils support important ecosystem services that promote our wellbeing, including from top left to bottom, provision of food and fibre, storage of carbon, filtering of water, and soilscapes offering aesthetic beauty.

Soil functions

Whilst soils have been traditionally managed with the single function of food production in mind, it is now increasingly recognized that soils must be managed for multiple functions that can also be considered ecosystem services, contributing to our well being and sustaining the functioning of the earth's life support systems. Healthy soils act as the biogeochemical engine at the earth's surface producing the nutrients that support our terrestrial ecosystems, filtering the water that falls as rain or is applied to land through irrigation, and recycling the waste we produce in ever increasing amounts. Soils are also the largest terrestrial carbon store, acting as a buffer to climate change. In the UK soils are estimated to store more than 10 billion tonnes of carbon. The loss of this store, in the form of CO_2 to the atmosphere, would be equivalent to more than 57 times the UK's greenhouse gas emissions for 2007.[iii] Soils also offer an important

cultural resource, preserving artefacts and heritage, supporting landscapes, providing aesthetic beauty, as well as recreation areas and sports fields. The faunal biodiversity of soils, long recognized, is an important gene pool from which we have extracted important medical resources such as antibiotics. Soils continue to provide new discoveries like the recent finding that the *Clostridium sporogenes* bacterium shows promise as a way of delivering cancer drugs into tumours.[iv] Therefore, the challenge is clear, to protect and manage soils so that they can maintain this functionality for a sustainable future.

Soil threats

Within the European Union, soils are increasingly regarded as an important natural resource to be protected like air and water. Over the last 10 years the European Commission has conducted a work program known as the 'Soil Thematic Strategy' regarding soil protection.[v] It explains why further action is needed to ensure a high level of soil protection, sets the overall objective of the Strategy and explains what kind of measures must be taken. The proposal for a Framework Directive[vi] sets out common principles for protecting soils across the EU. Within this common framework, the EU Member States can decide how best to protect soil and how to use it in a sustainable way in their own territory. The work of the Soil Thematic Strategy has identified 8 major threats to the soil resource including, erosion, organic matter decline, compaction, salinization, landslides, contamination, sealing (covering by infrastructure), and biodiversity decline.

In the UK, soil protection strategies for England, Scotland and Wales have identified major issues relating to soil protection. *Safeguarding our Soils: A Strategy for England*[iii] begins with an executive summary outlining the major threats to soils in England, which are identified as:

- Soil erosion by wind and rain
- Compaction
- Organic matter decline

In the subsequent chapters it makes the case for the importance of safeguarding our soils, and outlines areas of protection of strategic importance to England:

- Safeguarding our soils
- Better protection for agricultural soils
- Protecting and enhancing stores of soil carbon
- Building the resilience of soils to a changing climate
- Preventing soil pollution
- Effective soil protection during construction and development
- Dealing with our legacy of contaminated land
- And finally, future research and monitoring

In Wales, the Welsh Soil Action Plan consultation document highlights the principle threats to Welsh soils as being: climate change and decline in organic matter; soil loss to development (soil sealing); contamination, diffuse and gross (including acidification and eutrophication); soil erosion; degradation of soil structure; and soil loss by extraction.
Whilst in Scotland the Scottish soil framework ranked the following threats as being of most importance: climate change; loss of organic matter; soil sealing; acidification and eutrophication; loss of biodiversity; contamination by heavy metals; soil erosion; pesticides; compaction and structure; and salinisation.

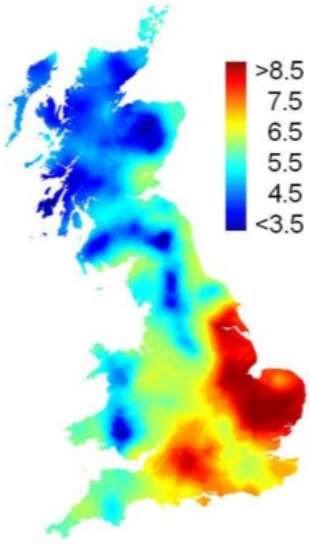
Protection of the soil resource and the maintenance of soil quality is a fundamental component of the recent UK government white paper 'The Natural Choice'.

Economic loss

It's hard to estimate the economic losses that society incurs as a result of soil degradation, but a few estimates have been made for the UK, and for the EU. For the UK, soil erosion due to wind and rainfall is estimated to result in the annual loss of ~ 2.2 million tonnes of topsoil resulting in a cost of ~£45 million; included in this is the estimated cost to British farmers of ~£9m a year in lost production.[iii] Organic matter decline due to cultivation has been estimated to cost ~£82 million per year by the Environment Agency in the same report. At the EU level, an Impact Assessment[vii] was undertaken which identified that soil threats, on an annual basis, cost the EU the following:

- erosion: €0.7 – 14.0 billion
- organic matter decline: €3.4 – 5.6 billion
- compaction: no estimate possible
- salinisation: €158 – 321 million
- landslides: up to €1.2 billion per event
- contamination: €2.4 – 17.3 billion
- sealing: no estimate possible
- biodiversity decline: no estimate possible

As a result of identifying these estimated economic losses, the interest in soil protection has increased and remains an important component of the EU 20/20 strategy.



pH variation across GB topsoil reflecting acid peat soils in the British uplands, and alkali soils overlying chalk and limestone in the SE of England.

The state & change of soils in Great Britain

In order to understand the condition of soils in Great Britain, the government, through NERC, Defra, and partners commissions the **Countryside Survey**. The survey, running since 1978, reports on the state and changes of ecosystems across Great Britain (GB) every ~10yrs. Results of the last survey (2007) have been reported.[viii] The major findings for soils reported that the national loss of soil organic carbon (0-15cm) previously reported[ix] could not be confirmed. However, both surveys showed a significant decline in carbon levels in arable agriculture. This is important because carbon plays an important role in maintaining soil structure and retaining water and nutrients in soils. Another finding was that soil pH has continued to recover from acidification across GB, indicating the success of the clean air act to reduce the input of acidifying compounds onto the land.

In the most recent survey (2007), there were an estimated 12.8 quadrillion ($1.28x10^{16}$) soil invertebrates present in the top 8 cm of the soils of GB during the time of sampling. Since the first sampling of soil biodiversity in 1998 a small reduction in the number of soil invertebrate broad taxa was found – which could suggest that there may be a declining trend in soil biodiversity. However, repeat sampling is required to ensure that seasonal conditions in the two sampling years including, land management, annual weather patterns or merely natural population variation do not explain the observed changes before any general trends can be validated. Maintaining soil biodiversity is important for disease regulation, waste recycling, and maintaining the gene pool from which we extract organisms used in human health care such as, for example, antibiotics.

Current research challenges

There are many research challenges with regard to the better management of soils. A recent report on soil health and sustainability[x] identified the following as some of the higher priority ones with researchers and stakeholders:

- Extending understanding of soil biodiversity and functions related to land management practices.
- Data mining of existing research (globally).
- Exploiting the use of sensors.
- Soil sensors for field measurement of variability.
- Preservation and utilisation of long-term field trial plots.
- Integrated studies of C, N, P, etc. from measurement to modelling.

A further challenge is to convey this information to stakeholders and decision makers in a way that is convenient and understandable to a broad cross section of society. Ecosystem service concepts have developed with this in mind, as a way to bridge science and policy through the use of a common valuation system and set of indicators. The ecosystems approach broadly defined

is, 'the benefits we obtain from nature.' These benefits can be valued, and it is becoming clear that valuation has a number of objectives:
1) To provide a natural asset check, so that policy makers can obtain a quick overview of the state of the natural environment, in a similar way to which GDP acts as an indicator for the state of the economy.
2) Valuation for decision support tools that help land managers and policymakers trade-off land use options in order to make decisions about future use.
3) Valuation for making payments for the delivery of ecosystem services by land managers and stewards from government resources.

Many people are wary of valuation, thinking decisions may simply come down to financial arguments, but valuation is a way of expressing the functional, aesthetic or moral benefit we obtain from something, and need not be monetary. Some of the advantages of valuation are that it highlights the importance of ecosystem functioning for mankind. Moreover, it may highlight specific importance of unseen, unattractive or unspectacular ecosystem services, which is often important for soils, where many services go unseen. The challenge for soil science is to develop the appropriate frameworks to convey the importance and value of soils within this ecosystems approach.[xi]

Concluding remarks

How should we respond? By cherishing and stewarding the land, and recognizing that soils provide important services for our health and wellbeing. Encouraging future urban development on brown field sites, and seeking to manage land in a way that conserves the soil resource rather than mines it, handing on good quality, healthy soils for future generations.

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