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Dust to dust? The importance of soil

"The nation that destroys its soil, destroys itself," said Franklin D. Roosevelt (President of the USA), February 1937.

Dark clouds roll over the land at one hundred miles per hour, engulfing and smothering everything on their path. They don't carry the much awaited rain, but choking dust. Not the ash spewed out of a volcano, or the particulate belched out of industrial and car exhausts; this dust is the farmland, crumbling away.

A giant dust storm threatens to engulf a village in the American Dust Bowl disaster of the 1930s.

Key words

soil

erosion

water storage

food security

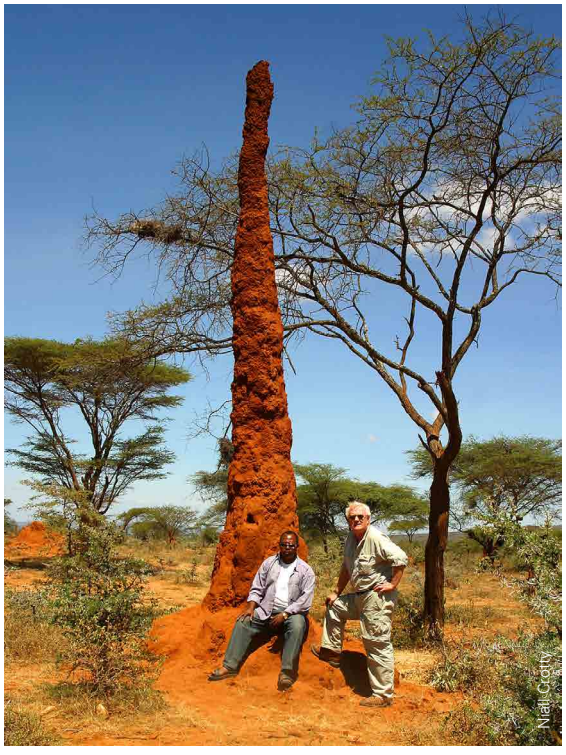
It's 1935 in the Great Plains of the United States, the area newly named 'The Dust Bowl'. Poor understanding of the Plains' ecology has led the authorities to assign to farmers as cropland these drought-prone, wind-swept prairies. Poor soil management (deep-ploughing and fallowing) followed by a few years of droughts have turned the unprotected topsoil into dust. Unprecedented dust storms ('black blizzards') are now ravaging the land and depositing tonnes of earth as far away as Chicago and New York. Entire communities are plunged into destitution, populations are displaced. From this ecological, economic and human disaster, the first legislation for the protection of soil, the Soil Conservation Act, is born.

Even now, few countries have passed legislation for the sustainable management of soil and, every year, 75 billion tonnes of crop soil worldwide are lost to wind and water erosion.

What is soil?

Soil is made, on average, of 5% organic matter (dead plant and animal material), 25% air, 25% water, and 45% mineral material (rock, sand, silt, clay). But soil is constantly changing: different proportions of air and water fill the pores between the solid grains, chemical reactions happen between its minerals components and within the millions of organisms that live in it all the time.

The formation of one cubic centimetre of new soil can take hundreds to thousands of years, thus making soil effectively a non-renewable resource. New soil is formed when 'parent' rock is exposed either by volcanic eruption, by uplift of the sea bed or by weathering (caused by wind, rain, ice or changing temperatures). Parent rock can also be deposited from elsewhere as gravel, sand or sediments of different sizes. The size of the particles will give the soil a different texture: sandy soils feels coarse and gritty; silty soils feel silky; clay soils feel sticky. Plant roots then bind the soil particles and split the rocks, while animals burrow into the soil, mix it and deposit faeces. Faeces and dead plants and animals are decomposed by fungi and bacteria which release their nutrients for new plant colonisers. This creates successions of plant, animal and microbial communities which are affected by and affect the evolving soil.



Termites build their homes from particles of soil – this spectacular mound is in southern Ethiopia.

Why should we care about soil?

We trample it, we cover over it, we call it 'dirt'. With a few pricey exceptions (beauty mud masks, for example), we don't value the soil under our feet. Still, everything we need in order to survive (food, clothing, shelter and water) comes from soil. 'Soil security' is increasingly being spoken about, because soil is unequally distributed across nations and provides us with a crucial range of services:

- Building materials. From peat to sand, from clay and gravel to the ancient Romans' fantastic *pozzolana*, most building materials come from soil.
- Food, animal feed, fibres, fuel and medicinal products. With the exception of hydroponic cultures, all crops are grown on soil. Soil provides plants with anchorage, water, oxygen, trace elements and symbiotic microorganisms which facilitate the absorption of micronutrients by plant roots. Food grown on soil which lacks micronutrients which are indispensable to human health (e.g. iodine, copper, lithium, magnesium, iron and zinc), will foster malnutrition, especially in those cases where the trace elements are essential for humans but not for plant growth (like selenium and iodine). Soil also buffers plant roots from temperature fluctuations.
- Water storage and purification. Un-compacted, healthy soils prevent flooding by allowing water to infiltrate and percolate instead of running off. Some soils can store in excess

Cultivation terraces, such as these in Puglia, Italy, retain rainwater and prevent soil erosion, allowing crops to be grown on steep hillsides.

of 400 mm of rainfall in their first meter of depth. Contaminants and pathogens are filtered out of the water during percolation, and microorganisms like *Enterobacter cloacae* can remove pollutants like selenium.

- Carbon storage. Soil organic matter stores more organic carbon than global vegetation and atmosphere combined. Soil is a key player in the global carbon cycle. Scientists are worried that, with global warming, increased activity of the microbial community in permafrost could release large quantities of the tundra's soil carbon. In an experiment, after only 1.5 years of warming, scientists observed a 38% increase in tundra microbial respiration.
- Disease protection through a diverse ecosystem. Soils host a quarter of our planet's biodiversity, most of which is as yet unstudied. Healthy soil contains millions of organisms including vertebrates, earthworms, nematodes, mites, insects, fungi, bacteria and actinomycetes. Few species occur in most soils, most species being limited to specific soil type or regions. Earthworms and termites increase crop productivity, symbiotic soil microbes increase plant nutrient uptake, fungi promote plant stress tolerance.

Most soil organisms pose no risk to human health and actually compete with the small minority or microorganisms which are pests, parasites or pathogens such as *Bacillus anthracis,* the agent of anthrax, *E.coli, Clostridium tetani* and parasitic nematodes. Ploughing and excessive fertilizer application decrease soil biodiversity and, as a consequence, protection against disease. Studies have shown that our immune system needs to be exposed to soil microorganisms in order to develop tolerance against allergies and scientists are looking at soil microbiota as a yet-untapped source of potential antibiotics and medicines (see Catalyst article on Teixobactin, Oct 2015).

The health of our soils

Every year 75 billion tonnes of crop soil are lost worldwide due to wind and water erosion and unsustainable agricultural practices. Current estimates put the percentage of global soil classified as moderately to highly degraded at 33%. The major causes of degradation are erosion, salination, compaction, acidification, loss of organic matter, soil sealing, chemical pollution and nutrient depletion. In the UK alone, the total cost of soil degradation is estimated at about £300 million per year.

The effects of the mismanagement of soil are felt far beyond the site of the disturbance: soil erosion by water and wind contributes to dust storms and the dispersal of soil microorganisms and pathogens for miles; the release of carbon from soil affects the planet's climate; the run-off and leaching of nutrients affects aquatic systems.

Considering the role played by soil in food security, climate change, human health, poverty alleviation and sustainable development, it is no surprise that the United Nations General Assembly declared 2015 the International Year of Soils with the purpose of raising awareness about this neglected resource. Understanding and appreciating the many services provided by the stuff under our feet is a first step towards using it responsibly.

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Actions to protect soil

- Prevent soil pollution.
- Avoid sealing the soil (covering it with impermeable material).
- Avoid compacting the soil.
- Reduce tillage to increase carbon storage in soil.
- Include cover crops to prevent erosion.
- Increase crop rotation to expand soil biodiversity.
- Prevent water erosion by practising terraced and contour farming (planting crops following the contour of the landscape).

2015 International Year of Soils

Look here!

2015 Year of Soils:
http://www.fao.org/soils-2015/about/en/

Take the soil quiz:
http://www.fao.org/soils-2015/news/news-detail/en/c/317128/

British Society of Soil Science: http://soils.org.uk/

Become a soil scientist:
http://soils.org.uk/what-soil-scientist-0

Global Soil Biodiversity Initiative:
https://globalsoilbiodiversity.org/

Soil Science Society of America The Year of Soils videos:
http://bit.ly/1DmbcMN