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Guest editorial: managing our soils: learning from the past to help feed a growing world population

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Editorial

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'Soils: where food begins' (Food and Agriculture Organisation, 2022)

The sustainability of global and UK food supply is linked to the sustainability of agricultural systems, and that depends on the sustainability of their soils. But soils are fragile, and in ecological studies at Rushcliffe Country Park, Nottingham, UK (GPS 5719231652) on 25 July 2022, we recorded a striking example of this fragility.

After a long period of hot dry weather cracks 1 to 2 cm wide and 20 cm deep had occurred in a control 5 m × 5 m plot, and in the surrounding field. But cracks did not occur in a plot which had since 2012 received 2 litres/m^2 per year of a compost based on farmyard manure. Although the grasses and forbs of both plots were scorched above ground level, those of the compost plot were taller and thicker, providing protection at ground level. There were mosses on the soil surface which were still green.

It was postulated that differences in vulnerability to cracking between plots may have been at least partly due to differences in soil organic matter content. Therefore, two soil samples per plot were taken to 14 cm depth and the samples pooled. For a volumetric analysis pooled samples were shaken in water in a measuring cylinder and left to settle for 24 h, after which the organic material had floated to the top. Gravimetric analysis was by loss on ignition of air-dried pooled samples. Carbonate values were included as indicators of inorganic carbon and of the mineral status of the plot soils.

Results of soil analyses

	Moisture	Organic matter		Carbonate
	g/kg	g/kg	% by volume	g/kg
Control	20.85	68.8	2	25.5
Composted	22.44	93.5	7	24.4

The larger difference in organic matter content between treatment and control by the floatation method may have been due either to the fibrous nature of the compost organic matter, or to the cruder analytical method, or both. The nitrogen fixing plant melilot (*Melilotus officinalis*, botanical family *Papilionaceae*) was present on the composted plot but not on the control plot. Thus, there could have been a positive feedback effect on the plant nutrient status of the plot. Because the plots were not replicated the data in the table could not be analysed by conventional statistical inference (Fisher and Yates, 1938; Jeffreys, 1961; Charles, 2020b), but they are part of a Bayesian description (Matthews, 1998) of a difference which was visually and ecologically stark and inescapable.

These observations link our work with other studies on soil care and agricultural sustainability, a brief history of which follows.

The history of agriculture, and that of the hunting and gathering which preceded it, provide comparisons of the sustainability of historic systems with that of modern techniques. The food acquisition systems of the pre-historic hunter gatherers (Tannahill, 1988; Charles, 2002) of the Middle Pleistocene (Larsen, 2000) could not be classed as sustainable since the process was extractive.

The cultivation of einkorn wheat (*Triticum monococcum*) and the domestication of the sheep (*Ovis aries*) occurred about 9000 BC (Charles, 2002). The goat and the pig (*Capra hircus* and *Sus scrofa* respectively) were domesticated about 7000 BC and cattle (*Bos taurus*) about 6000 BC. These developments led to settled life styles, but in Neolithic times if soil fertility began to fail populations cleared more forest and moved on, so that the system was not strictly sustainable. Over grazing and inadequate fallowing sometimes even led to a return to hunting (Miller and Wetterstrom, 2000).

About 700 BC the Greek poet Hesiod wrote that fallowing was a '…defence against disaster and a comfort to the children'. He also advocated diligent ploughing (Cartledge, 1998).

By the 3rd century BC, it had been realized by Greek agricultural writers that beans invigorated the soil (Shorrocks, 2017). But despite this agronomic sustainability break through, care of the soil in classical times was sometimes so neglected that it has even been suggested that one of the reasons for the fall of the Roman Empire was the abuse of its soils (Montgomery, 2017).

For more than a thousand years after the Romans left Britain the maintenance of soil fertility was achieved by leaving one field in three, or sometimes four, fallow in unfenced open field villages (Rundle, 1955; Charles, 2002). But this extravagant use of land was no longer acceptable once the industrial revolution meant that larger urban populations had to be fed.

Enclosure of the open fields created individual farms and permitted closer control over crops and livestock. It was therefore a significant development in the care of soils. Lyth (1989) and Atkins *et al.* (1999) described enclosure in Nottinghamshire, UK. Rundle (1955) described the survival of the open field system at Laxton, Nottinghamshire, where 711 ha was purchased in 1951 by the UK Ministry of Agriculture to preserve the heritage.

Charles (2020a) reviewed the history and biology of the crop rotations developed from the 18th century onwards, including the famous Norfolk (UK) four course rotation (wheat – turnips – barley – clover) pioneered by Charles 'Turnip' Townshend (1674–1738) of Raynham and Thomas Coke (1754–1842) of Holkham. The inclusion of clover (*Trifolium* spp., family *Papilionaceae*) in these rotations would have contributed to their soil sustainability by virtue of nitrogen fixation. Livestock utilized the clovers. The value of livestock manures in these rotations was stressed by Wiseman (1986), who pointed out that sometimes the profitability of 19th century livestock enterprises was based on the value of their manure. The livestock improver Robert Bakewell of Loughborough, UK, (1725–1795) took the value of manures so seriously that he occasionally wintered the livestock of his neighbours with their dung as his only return (Stanley, 1995).

It is interesting that Viscount Charles 'Turnip' Townshend is remembered for his crop rotations, even though his day job was Foreign Secretary (Wade Martins, 1990). That illustrates the significance of the turnip (*Brassica rapa*) (Francis, 2013) and of crop rotations, soil care and sustainable agriculture in British history.

The widespread use of chemical fertilisers contributed to the green revolution of the 1950s and 1960s and may have saved up to a billion lives according to Shorrocks (2017). However, following the publication of Rachel Carson's *Silent spring* (Carson, 1962), the organic movements, originally dating from the 1920s, grew in popularity and influence, and the Soil Association, founded in 1946, produced a set of guidelines in 1967. The International Federation of Organic Agriculture Movements was founded in 1972. Textbooks on organic farming began to appear, such as Lampkin (1990), Younie and Wilkinson (2001) and Gordon and Charles (2002).

World War II and the immediate post war years were periods of emphasis on productivity of the land in Britain. The Agriculture Act of 1947 created a research and advisory support structure in UK (Charles, 2002). Histories of these infra-structures by sector in Britain included that for poultry by Hewson (1986) and for pigs by Wiseman (1986) and Wiseman (2000). A textbook on dairy farming stressed the value of manure on arable land (Russell, 1952).

In the mid-20th century land utilization, including the hills and uplands, was regarded as important for UK food security and sustainability, and the analysis by Stapledon (1944) included the contributions of grazing animals. The continuing relevance of Stapledon's analysis to issues arising eight decades later is impressive.

Dangers to the sustainability of soils were pointed out and quantified by authors such as Montgomery (*loc. cit.*) and Parkinson (2003). Conservation agriculture aims to protect the soil while at the same time maintaining yields (Oliver, 2018). Oliver described its main characteristics as minimizing disturbance of the soil, maintaining organic residues and using relevant crop rotations.

Regenerative agriculture takes the concepts of conservation agriculture further, aiming not just to conserve but to rebuild soil health and structure. Giller *et al.* (2021) reviewed 79 references on regenerative agriculture, including its history and agronomy. Both systems discourage soil disturbance by using minimum tillage, but with cover crops and mulches. Both aim to minimize disturbance of soil organisms, and to encourage mycorrhizas. Sheldrake (2021) stressed that mycorrhyzas bind soils, increase water holding capacity and water infiltration, and reduce the leaching of plant nutrients.

Precision agriculture recognizes that fields are seldom uniform, therefore it advocates localized rather than whole field soil analysis and treatment. There is now a global organization for the subject (International Society of Precision Agriculture) and review books have been published: e.g. Oliver *et al.* (2018) and Zhang (2016). Oliver (2018) made the point that precision agriculture principles can be applied to sustainable agricultural systems. Charles (2021) claimed that some of the principles of precision agriculture were presaged by the cultivation of random strips within the three-field system of earlier centuries in England, because each strip of about 0.1 to 0.2 ha could be managed separately.

Stoate *et al.* (2017) described 25 years of the Allerton Project in Leicestershire, UK. They found that with reduced soil disturbance there were more earthworms and higher microbial biomass. Infiltration was improved and run off reduced in some fields.

Brown (2018), recorded his practical experiences of regenerative agriculture in North Dakota, USA. He offered some principles of soil health, including limited disturbance of the soil, avoiding bare soil, diversity of cropping in rotations and the inclusion of animals. Seed sowing on unploughed ground was with a disc drill. His cover crops were multi-species to encourage a synergy of mycorrhyzas and a range of rooting depths. To increase soil organic matter, he used mob grazing of cattle at high stocking rates moved frequently.

The average cost of ploughing in Britain was recorded as £55.73 to £67.09/ha, depending on soil type and whether contracted or not. Shallow discing was estimated to cost £37.17 to £54.36/ha (Redman, 2021).

The Sustainable Food Trust web site (2022) advocates grassland and grazing livestock as an integral part of sustainable farming systems. Fiennes (2022), working at the Holkham Estate, Norfolk, where Thomas Coke had farmed (see above), listed 12 suggested cover crops, including 7 nitrogen fixers.

The realization that soils are living habitats containing a range of organisms is not new, having been described in detail by Jackson and Raw (1966).

Our composted plot used a compost based on cow manure, so it is interesting that authors such as Stoate *et al.* (2017) and Brown

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(2018) stressed the integration of livestock in sustainable systems, and historic rotations such as the Norfolk four course included ruminant livestock. Yet some modern movements such as veganism advocate the ending of livestock farming. This would not be so readily sustainable, though there are soil improvement systems based on compost, cover crops and companion crops.

Conservation agriculture, regenerative agriculture and organic movements have all rejected monoculture. In addition, both conservation agriculture and regenerative agriculture have dispensed with the plough, yet ploughing has long been regarded as the basis of seed bed creation, as illustrated by the quote above from Hesiod.

Regenerative agriculture raises soil organic matter (Brown, *loc.-cit.*). This encourages earthworms, which Darwin (1881) described as the 'natural ploughs of the soil' (Darwin, 1881; Costa, 2017), thus anticipating no plough systems by a century! Thomson (1939) described the agricultural significance of earthworms as 'bringing up what was down and gradually bringing down what was up', as well as aerating the soil.

Parsons (2017) estimated that 1.5% of global fossil fuel consumption was used in the industrial fixing of nitrogen for fertilisers. Recent world events have made this process more expensive than it was then, thus enhancing the relevance of nitrogen fixing crops.

Does concern for soil care matter? In an analysis of present and future threats to civilization Tallin *et al.* (2017) identified potential food shortages as an example threat. Thus, the use of legumes to fix nitrogen, the encouragement of earthworms, limited soil disturbance, manures and composts, crop rotations and cover crops should be exploited to help feed growing world populations sustainably.

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References

Atkins J, Hammond B and Roper P (1999) *A Village Transformed. Keyworth 1750–1850.* Nottingham, UK: Keyworth and District Local History Society.

Brown G (2018) *Dirt to Soil: One Family's Journey Into Regenerative Agriculture*. White River Junction, Vermont: Chelsea Green Publishing.

Carson R (1962) *Silent Spring*. Boston: Houghton Miffin Harcourt.

Cartledge P (1998) *Ancient Greece*. Cambridge, UK: Cambridge University Press.

Charles DR (2002) *Food Farming and the Countryside: Past, Present and Future*. Nottingham, UK: Nottingham University Press.

Charles DR (2020a) Sustainable agricultural systems and farm animals: the historical and biological evidence. *Journal of Agricultural Science* **157**, 563–565.

Charles DR (2020b) The analysis of agricultural experiments: a brief history of the techniques of the 20th century. *Journal of Agricultural Science* **158**, 447–449.

Charles DR (2021) On farm experimentation: some historical harbingers. *Newsletter of the International Society of Precision Agriculture.* Edit. Tremblay, N.

Costa JT (2017) *Darwin's Backyard*. New York: Norton.

Darwin C (1881) *The Formation of Vegetable Mould Through the Action of Worms, with Observations on Their Habits*. London: John Murray, (abstract only seen).

Fiennes J (2022) *Land Healer*. London: Witness Books.

Fisher RA and Yates F (1938) *Statistical Tables for Biological, Agricultural and Medical Research*. Edinburgh: Oliver and Boyd.

Food and Agriculture Organisation of the United Nations (2022) World Soil Day, 5 December Available at fao.org/publications/highlights-detail/en/c/1599787/.

Francis SA (2013) *British Field Crops*, 2nd Edn. King's Lynn: Sally Francis.

Giller KE, Hijbeek R, Andersson JA and Sumberg J (2021) Regenerative agriculture: an agronomic perspective. *Outlook on Agriculture* **50**, 13–25.

Gordon SH and Charles DR (2002) *Niche and Organic Chicken Products: Their Technology and Scientific Principles*. Nottingham, UK: Nottingham University Press.

Hewson PFS (1986) Origin and development of the British poultry industry: the first hundred years. *British Poultry Science* **27**, 525–540.

Jackson RM and Raw F (1966) *Life in the Soil*. London: Edward Arnold.

Jeffreys H (1961) *Theory of Probability*, 3rd Edn. Oxford, UK: Oxford University Press (abstract only seen).

Lampkin N (1990) *Organic Farming*. Ipswich: Old Pond Publishing.

Larsen CS (2000) Dietary reconstruction and nutritional assessment of past peoples: the bioanthropological record. In Kiple KF and Ornelas KC (eds), *The Cambridge World History of Food*. Cambridge. UK: Cambridge University Press, pp. 13–34.

Lyth P (1989) *A History of Nottinghamshire Farming*. Newark: Cromwell Press.

Matthews RAJ (1998) Facts versus Factions: the Use and Abuse of Subjectivity in Scientific Research. Working paper, September 1998. The European Science and Environment Forum, Cambridge.

Miller N and Wetterstrom W (2000) The beginnings of agriculture: the ancient near East and North Africa. In Kiple KL and Ornelas KR (eds), *The Cambridge World History of Food*. Cambridge, UK: Cambridge University Press, pp. 1123–1139.

Montgomery DR (2017) *Growing A Revolution: Bringing our Soils Back to Life*. New York: Norton.

Oliver MA (2018) An overview of precision agriculture. In Oliver MA, Bishop T and Marchant B (eds), *Precision Agriculture for Sustainability and Environmental Protection*. Abingdon: Routledge, pp. 3–19.

Oliver M, Bishop T and Marchant B (2018) *Precision Agriculture for Sustainability and Environmental Protection*. Abingdon: Routledge.

Parkinson RJ (2003) Soil management and crop nutrition. In Soffe RJ (ed.), *The Agricultural Notebook*. Oxford: Blackwell Science, pp. 3–62.

Parsons J (2017) Can we fix it? *Biologist (columbus, Ohio)* **64**, 12–15.

Redman G (2021) *The John Nix Pocket Book for Farm Management 2022*, 52nd Edn. Melton Mowbray: Agro Business Consultants.

Rundle JR (1955) Laxton today. In *Agriculture*. Ministry of Agriculture, Fisheries and Food. London, UK: HMSO, pp. 170–172.

Russell KM (1952) *Fishwick's Dairy Farming*, 2nd Edn. London: Crosby Lockwood.

Sheldrake M (2021) *Entangled Life*. Dublin: Vintage.

Shorrocks VM (2017) *Conventional and Organic Farming: A Comprehensive Review Through the Lens of Agricultural Science*. Sheffield: 5M Publishing.

Stanley P (1995) *Robert Bakewell and the Longhorn Breed of Cattle*. Ipswich: Farming Press Books.

Stapledon RG (1944) *The Land Now and Tomorrow*, 3rd Edn. London: Faber and Faber.

Stoate C, Leake A, Jarvis P and Szczur J (2017) *Fields for the Future: 25 Years of the Allerton Project*. Fordingbridge: Game and Wildlife Conservation Trust.

Tallin J, Rees M and Price H (2017) Centre for the Study of Existential Risk, Cambridge, website. Available at en.wikipedia.org/wiki/Centre_for_the_Study_of_Existential_Risk.

Tannahill R (1988) *Food in History*. London: Penguin.

Thomson JA (1939) *Biology for Everyman*, vol. **1**. London: Reader's Union and J.M. Dent, pp. 152–155.

Wade Martins S (1990) *"Turnip" Townshend: Statesman and Farmer*. North Walsham: Poppyland Publishing.

Wiseman J (1986) *A History of the British Pig*. London: Duckworth.

Wiseman J (2000) *The Pig: a British History*. London: Duckworth.

Younie D and Wilkinson JM (2001) *Organic Livestock Farming*. Lincoln: Chalcombe Publications.

Zhang Q (2016) *Precision Agriculture Technology for Crop Farming*. Boca Raton: CRC Press.