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Science for Environment Policy

Intensive grassland farming could have deep effects: sequestering significantly less soil carbon

Huge amounts of soil carbon have been discovered up to 1 metre below grassland in a recent UK study. Yet most carbon inventories do not assess soil deeper than 30 cm. Furthermore, this research suggests that intensive management of grassland, involving high rates of fertiliser use and livestock grazing, may deplete carbon at these depths.

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Source: Ward, S.E., Smart, S.M., Quirk, H., Tallowin, J.R.B., Mortimer, S.R., Shiel, R.S., Wilby, A. & Bardgett, R.D. (2016). Legacy effects of grassland management on soil carbon to depth. *Global Change Biology*. DOI: 10.1111/gcb.13246.

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Globally, soil contains more carbon than all the Earth's plants and atmosphere combined. Much of this carbon can be found in soils beneath grasslands, which are estimated to cover 20–40% of the Earth's surface. Amongst biomes, grasslands are the third largest global store of carbon (after wetlands and boreal forests).

Grasslands — and the carbon they store — can be influenced by human activities, including intensive farming. However, there is uncertainty over the effects of land management and land use change on soil carbon stocks, partly because most studies only consider the top 30 cm of soil, which is easier to access. The IPCC's 2006 Guidelines for Greenhouse Gas Inventories recommend soil carbon accounting for the top 30 cm, but also advocate sampling beyond 30 cm. However, this deeper sampling rarely happens.

To help address this gap in knowledge, the researchers measured carbon in grassland soils at different depths of up to 1 metre across the UK. They assessed soil taken from 180 sites which represented a range of grassland types: acid, calcareous, mesotrophic and wet. At each site, they took samples from three different fields which were of the same soil type, but managed in different ways: intensively, extensively, or intermediately.

Intensively managed fields typically received over 100 kg of nitrogen fertiliser per hectare per year (N ha^{-1} yr^{-1}). They were heavily grazed by animals (stocking rate of 2–3.5+ livestock units (LU) per ha^{-1}), cut two or three times a year for silage and had low average plant diversity of just 10 species per m^{-2}. They had been managed intensively since the 1950s.

In contrast, extensively managed fields received less than 25 kg N ha^{-1} yr^{-1}, were lightly grazed (less than 1 LU ha^{-1}), were cut just once a year and had high plant diversity (average of 21 species per m^{-2}). They had been managed in a traditional way for many decades.

Intermediate land received 25–50 kg N ha^{-1} yr^{-1}, had stocking rates of up to 1.5 LU ha^{-1}, was also cut just once a year but had middling plant diversity (average of 15 species per m^{-2}).

Total percentage carbon in soil (organic and inorganic) was significantly lower in soils from intensively managed fields — 19% lower than in intermediately managed fields and 25% lower than in extensively managed fields. The researchers estimated that intensively managed grassland soil contained around 40.3 kg of soil carbon per square metre (kg C m^{-2}), going 1 metre below the surface, compared with around 41.4 kg C m^{-2} in extensively managed land, and around 44.6 kg C m^{-2} in intermediately managed land.

Based on their figures, the researchers estimate that 2 097 teragrams (teragram = 1 million metric tonnes) of carbon is stored in all UK grassland soils to a depth of 1 metre. This is over double the amount of carbon estimated if only the top 30 cm of soil is considered.

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Soil carbon stocks were higher in intermediately managed land than extensively managed land; the researchers suggest that this can be partly explained by differences in soil bulk density, likely due to compaction, and to fertiliser application rates. High levels of fertiliser reduce soil carbon through over-stimulation of plant decomposition rates, whereas modest levels of fertiliser allow plants to accumulate carbon by not over-stimulating decomposition.

There are many complex factors which influence soil carbon, and the study did not directly explore these; they include the impact of soil cultivation during reseeding of perennial ryegrass on intensively managed grassland, which releases large amounts of carbon (usually every 10 to 20 years), and also the findings of recent studies[1] into the importance of considering sampling depth when investigating soil organic carbon sequestration.

Other factors which affect how much carbon is in the ground include: the release of carbon dioxide by plants to the atmosphere, soil erosion, leaching into waterways and removal of grass by harvesting or grazing animals.

The study supports the IPCC's recommendation for deeper soil testing in carbon accounting. It also suggests that reducing the intensity of farming in the most highly managed and fertilised grasslands would bring future benefits for carbon sequestration.

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1. For example, Olson, K.R., Al-Kaisi, M.M. (2015). The importance of soil sampling depth for accurate account of soil organic carbon sequestration, storage, retention and loss. *Catena* 125: 33–3.