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Simple method to estimate soil carbon stocks in grassland

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Source: Manning, P., de Vries, F., Tallowin, J., *et al*., (2015). Simple measures of climate, soil properties and plant traits predict national-scale grassland soil carbon stocks. *J Appl Ecol*. DOI: 10.1111/1365-2664.12478

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Storage of carbon in soil helps to keep land fertile and regulates the climate, and is therefore an important ecosystem service. However, mapping of soil carbon stocks currently uses unreliable measures. This study used data from a national survey of English grasslands to show that soil carbon stocks can be accurately predicted using simple measures of soil and climatic conditions.

Two to three times more carbon is stored in soil than in vegetation or the atmosphere. The storage of carbon in soil is an important ecosystem service, playing a vital role in climate regulation and soil fertility. Determining the amount of carbon in soils is therefore important for effective land management, and to avoid the creeping depletion of soil carbon stocks. Calculating this currently relies either on unreliable proxies, such as land cover (e.g. by assuming that all grasslands or forests have the same stocks), or on labour intensive direct measurements.

The key to improving these estimates is knowledge of the factors that determine soil carbon distribution. These include climate, which controls the metabolism of flora and fauna and soil properties; the physical (abiotic) properties of soil such as texture and pH, which influence plant growth and microbial activity; and land management, which influences soil carbon cycling.

In this study, researchers set out to identify soil carbon storage factors in grasslands, which cover around 30% of the Earth's land surface. In the UK, where this study was conducted, grasslands cover 36% of the land surface and contain approximately 32% of national soil carbon stocks.

The researchers sampled 12 English regions during June and July 2005. In total, they sampled 180 fields, representing the four main grassland types in the UK: acid, calcicolous (rich in calcium), mesotrophic (moderately fertile) and wet. The researchers took soil samples 7 cm beneath the surface – the sampling depth which DEFRA recommends for assessment of soil abiotic properties in grassland. The samples were then analysed for moisture content, pH and total carbon content.

The researchers also identified the different plant species in the fields and estimated the percentage cover of each species in each field, as plant community composition is important for determining the rates of carbon input into soil and its turnover within the soil.

Next, the authors generated statistical models to describe the patterns of carbon. The models quantified the ability of several soil abiotic factors and plant traits – primary regulators of soil carbon storage – to predict the amount of carbon in the soil. The models also accounted for varying climatic conditions using long-term climate data from Met Office UKCP09 databases.

Values for plant traits, including leaf dry matter content, growth rate and leaf nitrogen content, were assigned to all species identified in the fields. The grassland survey, climate and trait data were then combined into a single dataset and used to generate a statistical model. A separate model was created to describe the carbon in a range of different size fractions, as well as total carbon.

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Comparing the models, the researchers found that surface soil stocks could be accurately predicted at the regional and national scales from plant traits, soil conditions and climate. The results also showed that different size fractions of carbon are controlled by different factors. For example, carbon stocks in soil of intermediate particle size (50 – 250 µm) could be best predicted by mean annual temperature, soil pH and soil moisture content. Carbon stocks in soil of smaller particle size (0.45 – 50 µm), which tends to be highly stable, was best explained by soil pH and leaf nitrogen content.

These findings show that regional and national patterns of carbon in soil can be predicted using simple and readily available measures of the environment and plant traits. This approach could significantly improve soil carbon predictions on the local to landscape scale (1 – 100 000 km^2), supporting management strategies to protect and enhance carbon storage in soil.

The authors say that their method is intended to provide baseline data for carbon stocks and their stability, and in its current form is not able to detect short-term, management-induced changes to carbon. For these purposes, they recommend the use of dynamic models to form predictions, as well as direct measurement. However, they say their method is useful in setting the baseline conditions for such models.

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