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Attributing spatial and temporal changes in soil C in the UK to environmental drivers

Amy Thomas (1), Bernard Cosby (1), Sam Quin (2), Pete Henrys (1), David Robinson (1), and Bridget Emmett (1)

(1) Centre for Ecology and Hydrology, Bangor, UK, (2) Centre for Ecology and Hydrology, Lancaster, UK

The largest terrestrial pool of carbon is found in soils. Understanding how soil C responds to drivers of change (land use and management, atmospheric deposition, climate change) and how these responses are modified by inherent soil properties is crucial if we are to manage soils more sustainably in the future. Here we attempt to attribute spatial and temporal changes in UK soil C to environmental drivers using data from the UK Countryside Survey (CS), a national soil survey across England, Scotland and Wales repeated in 1978, 1998 and 2007. A mixed model approach was used to model soil C concentration (g C kg-1) and density (t C ha-1) and their absolute changes for the time periods 1978-1998, 1998-2007 and 1978-2007 across the CS sites using a variety of explanatory variables: soil (parent material, pH, moisture, Olsen-P, Shannon Diversity Index); atmospheric deposition (nitrogen and sulphur); climate (growing degree days and rain); and land use (aggregate vegetation class).

Spatially, prediction of soil C concentration was good; soil moisture, pH, vegetation class and dominant grain size were all significant predictors. Field capacity also appeared to be important; however this data was only collected for a fraction of sites. N% was also strongly related to soil C concentration and density, as would be expected due to coupling of C and N in soil OM pools. Although N may drive soil C through impact on plant productivity, this cannot be separated from correlated C and N losses with OM decomposition, and hence N was not included as a driver for modelling. Predictive power for C density is not as strong as for concentration, which may reflect nonlinear relationships not represented by the modelling approach.

Temporally, change in soil C is more difficult to explain, and model predictive power was lower. Change in soil pH was important in explaining change in C concentration and density, along with change in atmospheric deposition; decrease in deposition and associated soil acidity (increase in pH) was associated with a decrease in soil C concentration and density. Change in soil moisture or rainfall was also important. Inherent soil and site properties such as soil texture, vegetation class and parent material appeared to contribute most to the prediction of soil C change through modulation of the relationship between change in soil C and change in pH.

Including anthropogenic and natural drivers in models of soil C stocks and changes in the UK enables assessment of the relative importance of each across the UK CS sites, however interactions among the drivers are more difficult to disentangle. Given the statistical significance of a number of drivers and soil variables in predicting soil C stocks and changes in the UK, it is important that these continue to be measured to allow better model development and more reliable predictions of future soil C conditions.