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Reduction in acidic deposition drives soil carbon change

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Soils are the largest terrestrial store of carbon (C) and therefore even small changes in the C stock could lead to significant increases in atmospheric CO_2 concentrations accelerating climate change; moreover, the structural integrity and functionality of soils are closely associated with C content. Not only is identifying trends in soil C storage important, but also to understand what is driving the trends, spatially and temporally so that we can manage soils more sustainably in the future.

Three soil surveys have taken place in the UK but identifying a consistent trend in the soil C stock has been difficult given their conflicting results. The National Soil Inventory (NSI) found carbon was lost from top soils (0-15 cm) in England and Wales between 1978 and 2003. However these results have not been confirmed by either the Countryside Survey, which found no overall change in top soil C (0-15 cm) concentration between 1978 and 2007 for GB or any of the three individual countries (Scotland, England and Wales) and the NSI Scotland, which found no change in soil C (0-100 cm) density across Scotland over a 19-31 year period.

Here we attempt to attribute spatial and temporal changes in UK soil C to environmental drivers using data from CS. A mixed model approach was used to model soil C concentration (g C kg-1) and density (t C ha-1) and the associated absolute change for the time periods 1978-1998, 1998-2007 and 1978-2007 across the CS squares using a variety of explanatory variables: soil (parent material, pH, moisture, %N, C:N, Olsen-P, Shannon Diversity Index); atmospheric deposition (nitrogen and sulphur); climate (growing degree days and rain); and land use (aggregate vegetation class and broad habitat).

Spatially, soil C concentration and density were well described by soil moisture, %N, pH, Olsen-P and broad habitat. Temporally, the change in soil pH was the most consistent variable explaining change in C concentration and density across the three time periods 1978-1998, 1998-2007 and 1978-2007 with a negative relationship i.e. a decrease in soil acidity (increase in pH) associated with a decrease in soil C concentration and density. The change in pH was attributed to changes in land use and atmospheric deposition, particularly sulphur. Land use change was an important variable driving change in C concentration and density. However, the significance was lost in models using all available variables (1998-2007) as change in %N, soil moisture, C:N ratio and Olsen-P became more important suggesting nutrient status is closely linked to vegetation.

We provide evidence at a National scale for the recovery of soil from acidification, which is linked to sulphur deposition which has been declining across the UK since its peak in the 1970s. This highlights the need to consider air pollution control policies on soil C and develop integrated monitoring, research and modelling approached across policy areas. Given the significance of numerous soil variables in the 1998-2007 model, it is imperative that these continue to be measured to allow better model development and predictions of soil C Nationally.