

12. Statistical analysis of NSI soil carbon changes in relation to climate and land management changes (WP 2.8)

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12.1 Introduction

Large losses of carbon from soils across England and Wales have been found in the samplings of the National Soil Inventory (NSI) between 1978 and 2003 (Bellamy *et al.* 2005). Changes in detailed land management within the broad land use categories recorded at the time of the sampling will undoubtedly have contributed to the carbon changes and there are likely to be complicated interactions between land use/management and climate change. The main objective of the first year of this study was to identify NSI sites where either detailed information on land management was available or the land management could be assumed.

12.2 Identification of study sites

A wide range of sources of information were examined:

Aerial photographs were available for an area of the Yorkshire Moors for a number of years from 1960 to 2000. Three NSI sites that had been resampled were within the area of the photographs for the years 1989 and 1995 (see Appendix 5). For the two upland heath sites it was possible to identify the sites on photos for 2000 although the rectification was not very good. The photographs were examined and it was concluded that the site under permanent grass was still under permanent grass in 1995 – two years before the resampling. However this did not give us any information on the management – such as stocking rates or hay cutting regime. More interesting were the two upland heath sites where it was apparent that burning had occurred at or close to both sites between the two samples being taken. The techniques of Yallop *et al.* (2006) were used to determine the age of the burnt areas shown in Table 12-1. This burning management could have contributed to the loss in soil carbon shown at both sites which were sampled 20 and 22 years apart. However, with only two sites it will be impossible to determine whether this loss in carbon was due solely to the burning practices or an interaction between that and climate change. Data from a similar upland site which is part of the Environmental Change Network (ECN) and which has not been burnt should be obtained within the next week or two and will be examined for similar trends.

The Countryside Survey (data from CS provided by the Centre for Ecology and Hydrology under license (www.CS2000.org)) had 1314 sites where measurements were taken in 1990 and 1999 in England and Wales and for which some management data was available. The positions of these sites were compared to the NSI sites and no CS site was closer than 1.9km to a resampled NSI site so will not provide any relevant information.

Table 12-1: NSI resampled sites

NSI_Site ID	Date of original sampling	Date of resampling	Original Organic Carbon (%)	Resampled organic carbon (%)	Land use	Management identified from aerial photos
11283	08/03/1983	31/03/2003	50.3	47.1	Upland Heath	Burnt 1-3yrs prior to 1989, recovering 1995, not burnt up to 2000
11284	27/01/1983	10/03/1997	5.8	5.44	Permanent Grassland	Permanent grass 1989/ hay cut 1995
11143	08/07/1981	11/04/2003	54.8	47.0	Upland Heath	Not burnt by 1989, still not burnt by 1995, but very close to burnt areas in both years

Eleven upland NSI sites in Wales that had been resampled were visited again in 2005 and soils sampled as part of an MSc project (Vernik 2005). Unfortunately due to limited resources the land management history at these sites was not investigated so these sites cannot be included in our analysis.

Fourteen resampled NSI sites within the broad land use class 'Arable' were revisited in 2003 to collect data for a PhD project (Verheijen 2005). Some information on land management before and between the two samples was gathered. This information included: when burning of straw was stopped, whether straw was incorporated or removed from the field, tillage techniques, manure applications and some information on cropping cycles.

As part of a Defra project (SP0546) 28 soil sample sites which had already been visited on two previous occasions as part of the national map program were again revisited and soil samples taken. Although these were not part of the NSI dataset there is land management information available and the soil samples taken were analysed for organic carbon content.

There are some permanent experimental sites across England and Wales for which detailed land management information is available. Four such sites which are described in a DETR report (contract EPG1/1/39) (2000) were compared to the resampled NSI points but none of these sites are within 1km of any NSI site.

Data and site information from the ECN and from the Forest Inventory should be made available to us within the next few weeks. We hope that the forest inventory sites will give information on forest and woodland management over the period between the samplings so that even if the sites are not close to the woodland NSI sites it will allow some management methods to be assumed for these sites. There are 123 NSI sites with land use deciduous/mixed woodland and 111 sites under coniferous woodland.

12.3 Reconstruction of daily climate and soil moisture datasets for each site

Monthly records of climate including temperature, rainfall and solar radiation have been obtained for every NSI point from 1960 to 2005 and work is progressing on investigating the building of soil moisture records in collaboration with the NERC funded project ‘An improved empirical model of soil carbon dynamics in temperate ecosystems’.

12.4 Initial statistical modelling

Investigation into possible statistical techniques has been made and the techniques to be applied will include hierarchical models to investigate the relationships between the change in organic carbon and other soil and climate properties. These models will allow the change at a site to be related to the other properties of that site including land management. The use of various software tools has been investigated – we shall use WinBugs (2004) to apply hierarchical models using Bayesian methods and MCMC techniques.

12.5 References

- Bellamy, P.H., Loveland, P.J., Bradley, R.I., Lark, R.M. and Kirk, G.J.D. (2005). Carbon losses from all soils across England and Wales 1978–2003. *Nature*, **437**, 245–248.
- Yallop, A.R., Thacker, J.I., Thomas, G., Stephens, M., Clutterbuck, B., Brewer, T., and Sannier, C.A.D. (2006). The extent and intensity of management burning in the English uplands. *Journal of Applied Ecology*, **43** (6), 1138–1148.
- Vernik, T. (2005). *Factors controlling carbon loss in soils in upland Wales*. MSc thesis, Cranfield University
- Verheijen, F. (2005). *On-farm benefits from soil organic matter in England and Wales*. PhD thesis, Cranfield University
- Bradley, R.I., (2005). *SP0546 : Soil Organic matter as a headline indicator of soil health*. Defra report
- DETR (2000). *Carbon Sequestration in Vegetation and Soils*. CEH Edinburgh

[WinBugs software](#) 1996-2004