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**INSTITUTE OF TERRESTRIAL ECOLOGY**

**MASQ: MONITORING AND ASSESSING SOIL QUALITY**

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## **Summary**

The first year of the Monitoring and assessing soil quality project (MASQ) which forms part of the Countryside Survey 2000 Module 6: Soils and Pollution has been successfully completed. Protocols of soil sampling, processing and storing CS2000 soil samples were developed, tested, completed and modified, where appropriate. All soil cores for microbial and organics analyses have been frozen, all cores of soil fauna have been extracted and the faunal samples are stored in 70% ethanol and all cores for other chemical analyses have been processed ready for analyses. All soil pH and loss-on-ignition analyses have been carried out and all data have been entered onto the CS2000 soils data base on Microsoft Access and these data have been cross-checked. Appropriate links have been set up between the CS2000 soils data and the CIS to enable analyses by land class and region. The 1978 soils data have been checked and entered into Microsoft Access. A WWW page was produced for CS2000.

## **1. Background**

The Royal Commission on Environmental Pollution Report on Soil Sustainability (1996) identified the development of indices of soil biological activity and diversity as a key research priority. The major difficulty in developing such indices is the need for baseline data from which a set of standards can be developed. A recent review by ITE (SOILPACS, 1996) has shown that existing data are inadequate to develop bioindicators of soil quality, as the data are poorly structured and inconsistent in methodology and objectives. A nationwide survey is necessary if we are to establish a comprehensive baseline dataset. This task requires considerable logistical commitment, since soil biological sampling is meaningless without detailed site information. In addition, issues related to the contamination of soil by past, present and future economically valuable activity involving chemical use and disposal, are proving difficult to resolve in the absence of a framework of national information on soil contamination that is related to land use type.

Countryside Survey 2000 (CS2000) provides a cost-effective framework for integrating a soil biological survey with existing and subsequent soil and land use data status and for a comparison with soil data from the 1978 Countryside Survey (pH, loss on ignition, basic soil descriptions). The programme of sampling would be targeted to enable the CS2000 field surveyors to re-sample X-plots used for soil sampling in the 1978 survey (ca. 1280 sites). The surveyors would be trained to collect suitable soil material for subsequent laboratory evaluation of soil pH, carbon content, faunal and microbial diversity and soil heavy metal and organic contents.

## **2. Project purpose and objectives**

### **2.1 Project purpose**

To provide good quality data on soil chemical and biological properties for the development of national databases and to improve the understanding of links between soil biology, chemistry and the wider environment to support the development of suitable, effective strategies and policies relating to soil quality.

### **2.2 Objectives**

1 To provide a national overview of chemical and biological soil properties and a baseline against which specific sites can be compared by carrying out a programme of soil sampling, at the locations used in the CS2000, by the field surveyors operating under the CS2000.

2 To measure pH and soil carbon content and carry out a range of chemical analyses and a laboratory evaluation of faunal diversity and microbiological status to provide a baseline for the monitoring and assessment of soil quality in England and Wales.

3 To integrate information on chemical and biological properties and to look at it in terms of soil quality assessment and the wider terrestrial environment.

### **2.3 Objectives for 1998-99**

#### **Protocol development, training, sampling and immediate processing**

- ◆ Identify appropriate existing, and development of new, protocols for field sampling and subsequent laboratory processing of samples.
- ◆ Development and produce tailor-made sampling for the CS2000 survey teams;
- ◆ Increase the capacity of existing laboratory facilities;
- ◆ Train field survey teams;
- ◆ Sample processing and appropriate storage of samples;
- ◆ Develop databases for soil chemistry, biota and supporting data;
- ◆ Produce a scoping study for the chemical analyses to consider potential substances, suitability of analytical methods, quality assurance methods and cost.

### **3 Progress**

#### **3.1 Identify protocols for field sampling and laboratory processing**

This task was completed by May 20<sup>th</sup> 1998. Modifications to the MASQ extraction and preparation protocols for biotic and chemical analyses were identified during the processing period and have been edited into the protocol sheets. A revised copy of the protocols was included in the third quarterly report. The sampling equipment and protocols to be used by the CS2000 surveyors were tested at both Merlewood and at the ECN site at Moorhouse by ECN staff. The final protocol was incorporated in the CS2000 sampling handbook in early May.

#### **3.2 Develop and produce tailor-made sampling kits**

From April to May 22<sup>nd</sup> 1998, several people worked on the preparation of the field sampling kit for each survey team (30 in total) and each team leader (6). Each survey team kit consisted of all sampling items additional to those already in the CS2000 field kit (e.g. cool box, knife, labels, pens) and a copy of all sampling protocols. Each team leader was issued with complete packs for all squares to be sampled in their area. Each pack contained stamped addressed envelopes to ITE Merlewood for each X plot, which each contained two white cores plus plastic stoppers in labelled plastic bags, one each for faunal and microbial samples, and a black plastic core for the soil chemistry sample. During April and May, over 1000 m of plastic pipe were cut to size!

#### **3.3 Increase the capacity of existing laboratory facilities**

The renovated MASQ laboratory proved ideal for the processing of such a large number of samples; a large store at Merlewood was renovated to provide the necessary space for processing, extracting and storing the large number of soil samples expected from CS2000. This required a substantial amount of work to up-grade the electricity supply and install suitable benching and storage facilities for a large number of preserved specimens.

### **3.4 Train field survey teams**

A training session was held at The Crooklands Hotel, Cumbria on the 22nd of May 1998, during the CS2000 Training Course for field surveyors, when the use of all equipment was discussed and then demonstrated in the field.

### **3.5 Initial sample processing and appropriate storage of samples**

*Field sampling:* The CS2000 surveyors carried out the soil sampling to schedule and with few problems. Communication between the surveyors, co-ordinators and the samples processors meant that any outstanding sampling issues (e.g. numbering changes) were resolved quickly. The field sampling was completed by the end of October 1998 and the field equipment has been returned to ITE Merlewood. Outstanding CS2000 squares are to be visited in summer 1999. This will result in ca. 125 soil samples being sent to ITE Merlewood.

*ITE Merlewood processing:* Two full-time processing staff processed the CS2000 cores as they arrived at ITE Merlewood and entered the weekly data from the log-in sheets onto an EXCEL spreadsheet. A third (part-time) member of staff verified the 1978 soils data and monitored the progress of the fieldwork. The processing and storage of samples commenced on the 28<sup>th</sup> May 1998 and was completed in early November 1998. The soil faunal and microbial cores arrived at an average rate of 50 per week while the soil chemistry cores arrived in larger numbers in a less regular manner when transport was available. The last soil sample from the 1998 field survey was delivered to ITE Merlewood on the 28<sup>th</sup> of October 1998. All microbial/organic compound cores have been frozen and are readily accessible by date. All faunal extractions were completed on the 2<sup>nd</sup> of November 1998 and all samples are now stored in 70% ethanol within air-tight vials in a flammables cupboards. The cores from this have been retained, air-dried in sealed bags. Samples for chemical analyses have all been air-dried, sieved and stored in plastic containers ready for dispatch to the analytical laboratories. Summary statistics for the number of samples expected and received from CS2000, by region, squares, soil type and ITE Land Class are presented in Tables 1 to 4.

Table 1: Summary table of the number of soil samples, by region, expected and received from CS2000 for chemical analyses (pH, LOI and heavy metals), soil microbial assessments/ organic chemical analyses and soil zoological assessments. A further 125 samples will be obtained from Scotland during summer 1999.

Number of samples	TARGET	Chemistry	Microbial +Organics	Zoology	Chemistry %	Microbial +Organic %	Zoology %
England & Wales	725	633	629	630	87.31	86.76	86.90
Scotland	530	347	351	352	65.47	66.23	66.42
Total	1255	980	980	982	78.09	78.09	78.25

Table 2. Summary table of the expected and completed number of CS2000 squares sampled for soil by region and subsequent analyses required.

Complete squares (sets of 5)	TARGET	Chemistry	Microbial +Organics	Zoology
England & Wales	145	117	117	117
Scotland	106	57	57	57
Total	251	174	174	174

Table 3. Summary table of the number of soil samples, by soil type\*, expected and received from CS2000 for chemical analyses (pH, LOI and heavy metals), soil microbial assessments/ organic chemical analyses and soil zoological assessments.  
\*soil type from 1978 Countryside Survy data.

Soil type (1978)	Region	TARGET	Chemistry	Microbial +Organic	Zoology	Chemistry %	Microbial +Organic %	Zoology %
brown earth	England & Wales	330	282	278	279	85.45	84.24	84.55
peat	England & Wales	16	14	15	15	87.50	93.75	93.75
ranker	England & Wales	11	10	8	8	90.91	72.73	72.73
podzol	England & Wales	65	58	60	60	89.23	92.31	92.31
rendzina	England & Wales	20	18	18	18	90.00	90.00	90.00
gley	England & Wales	276	244	243	243	88.41	88.04	88.04
tba	England & Wales	7	7	7	7	100.00	100.00	100.00
brown earth	Scotland	123	83	82	83	67.48	66.67	67.48
peat	Scotland	124	88	88	88	70.97	70.97	70.97
ranker	Scotland	65	37	38	38	56.92	58.46	58.46
podzol	Scotland	102	75	76	76	73.53	74.51	74.51
gley	Scotland	111	61	62	62	54.95	55.86	55.86
tba	Scotland	5	3	5	5	60.00	100.00	100.00
TOTAL	All regions	1255	980	980	982	78.09	78.09	78.25

\* tba = to be assigned



Table 4. Summary table of the number of soil samples, by ITE Land Class\*, expected and received from CS2000 for chemical analyses (pH, LOI and heavy metals), soil microbial assessments/organic chemical analyses and soil zoological assessments.

\*standardised on 1990 ITE Land Classification.

ITE Land Class	Region	Target	Chemistry	Microbial +Organics	Zoology	Chemistry %	Microbial %	Zoology %
1	England & Wales	30	30	30	30	100.00	100.00	100.00
2	England & Wales	50	45	45	45	90.00	90.00	90.00
3	England & Wales	55	49	49	49	89.09	89.09	89.09
4	England & Wales	20	15	15	15	75.00	75.00	75.00
5	England & Wales	15	11	11	11	73.33	73.33	73.33
6	England & Wales	45	36	36	36	80.00	80.00	80.00
7	England & Wales	45	39	35	35	86.67	77.78	77.78
8	England & Wales	34	30	31	31	88.24	91.18	91.18
9	England & Wales	55	46	45	44	83.64	81.82	80.00
10	England & Wales	60	56	54	56	93.33	90.00	93.33
11	England & Wales	60	51	51	51	85.00	85.00	85.00
12	England & Wales	24	22	22	22	91.67	91.67	91.67
13	England & Wales	30	27	30	30	90.00	100.00	100.00
15	England & Wales	25	15	16	16	60.00	64.00	64.00
16	England & Wales	30	25	25	25	83.33	83.33	83.33
17	England & Wales	50	48	48	48	96.00	96.00	96.00
18	England & Wales	25	25	25	25	100.00	100.00	100.00
19	England & Wales	15	17	15	15	113.33	100.00	100.00
22	England & Wales	15	15	15	15	100.00	100.00	100.00
23	England & Wales	15	15	15	15	100.00	100.00	100.00
25	England & Wales	10	10	10	10	100.00	100.00	100.00
tba	England & Wales	17	7	7	7	41.18	41.18	41.18
7	Scotland	25	21	20	21	84.00	80.00	84.00
13	Scotland	15	15	15	15	100.00	100.00	100.00
18	Scotland	5	3	4	4	60.00	80.00	80.00
19	Scotland	5	5	5	5	100.00	100.00	100.00
21	Scotland	45	27	27	27	60.00	60.00	60.00
22	Scotland	35	27	27	27	77.14	77.14	77.14
23	Scotland	34	23	22	22	67.65	64.71	64.71
24	Scotland	40	28	28	28	70.00	70.00	70.00
25	Scotland	49	29	29	29	59.18	59.18	59.18
26	Scotland	39	17	18	18	43.59	46.15	46.15
27	Scotland	43	23	23	23	53.49	53.49	53.49
28	Scotland	40	24	24	24	60.00	60.00	60.00
29	Scotland	44	35	38	38	79.55	86.36	86.36
30	Scotland	35	15	15	15	42.86	42.86	42.86
31	Scotland	35	27	27	27	77.14	77.14	77.14
32	Scotland	30	25	24	24	83.33	80.00	80.00
Tba	Scotland	11	2	4	4	18.18	36.36	36.36
tba				9	9			
TOTAL	All regions	1255	980	980	982	78.09	78.08765	78.24701

tba = to be assigned

### 3.6 Develop databases for soil chemistry, biota and supporting data

The requirements for user-access and data storage have been discussed with John Watkins (CS2000 Module 13) and, consequently, the best methods to integrate the MASQ data with the 1978 soils data and CS2000 survey data are being assessed. Locational, data, pH and loss on ignition for all CS2000 samples and the 1978 soils data were initially entered onto Microsoft Excel spreadsheets. These have now all been transferred into a Microsoft ACCESS database with a link to the main CS2000 database. John Watkins has provided technical assistance with this task and provided the appropriate access authorities. John Watkins, Mark Garnett and Helaina Black carried out the first stage of data verification in November 1998 and all anomalies with square and plot numbers have been resolved. All data have been copied onto a CD-ROM that is now stored off-site. Further copies will be made on a regular basis.

### **3.7 Produce scoping study for the chemical analyses to consider potential substances, suitability of analytical methods, quality assurance methods and cost.**

Four metals were identified for analyses (Pb, ZN, CU, Cd) at the outset of MASQ. Subsequently, a list of additional metals and a full list of organic compounds was drawn up, in collaboration with the Environment Agency, for discussion purposes. The final suite of analyses will be determined in future discussions with DETR and the EA.

## **3.8 Sample analyses**

### **3.8.1 Soil pH and carbon content by loss-on-ignition analyses.**

Soil pH has been measured for all CS2000 soils that were taken for chemical analyses (Table 1). Two measurements have been made; the first on a sub-sample of each soil on arrival at ITE Merlewood ("wet" pH) and the second, on a sub-sample after air-drying, sieving. Loss-on-ignition (LOI) has been carried out on all soils sampled for chemical analyses (Table 1). Histograms indicating the range of values obtained for soil pH and LOI are presented in Figures 1 and 2, respectively. All data were initially entered onto Microsoft Excel. When all analyses were completed in November 1998, the data were checked as above and transferred into the Microsoft Access CS2000 chemistry database.

Figure 1 Histogram of soil pH values from CS2000

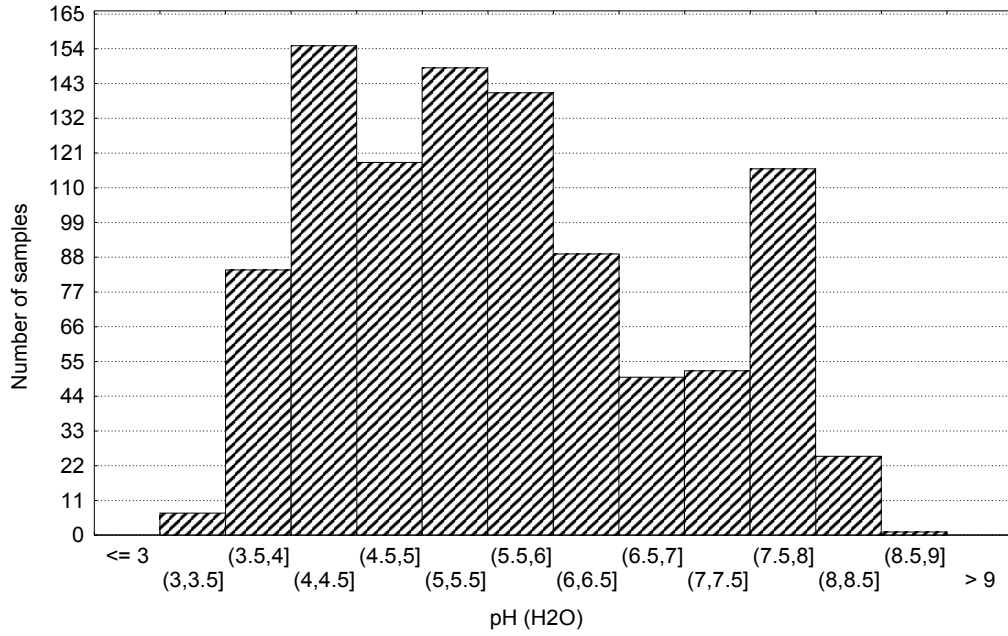
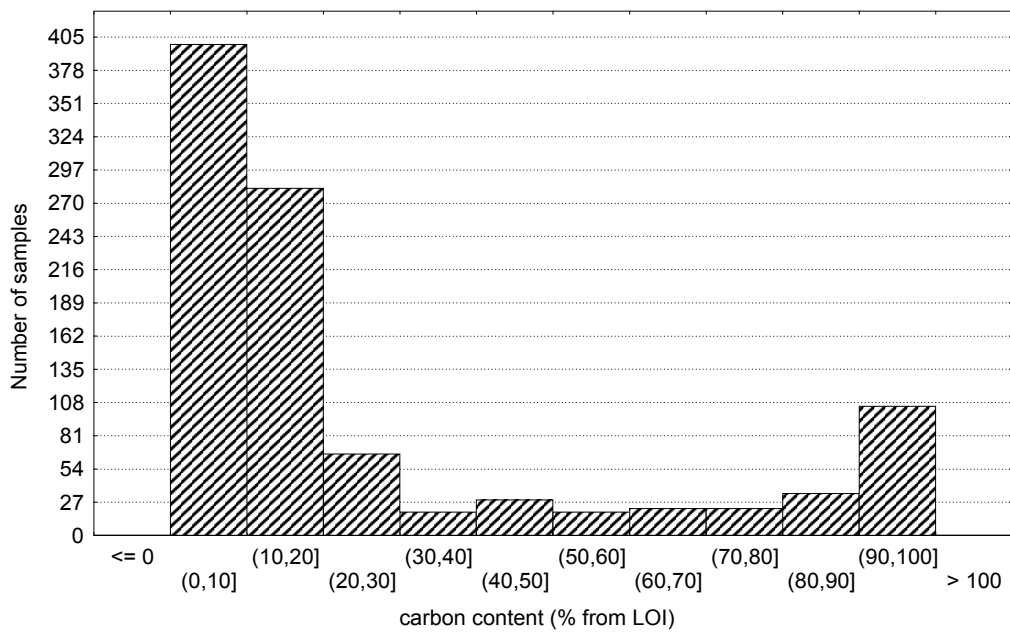


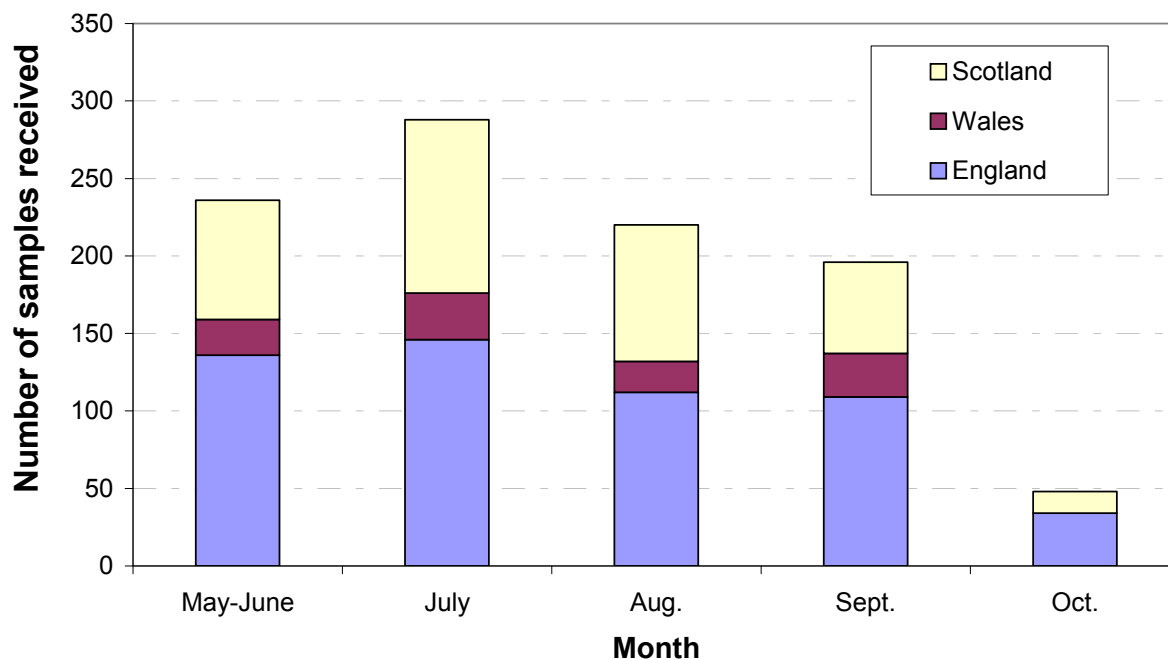
Figure 2 Histogram of soil carbon content (% from loss-on-ignition) from CS2000



### 3.8.2 Soils microbial community

The number of samples received each month during the 1998 field survey for soil microbial, and organics, analyses is shown in Figure 3. Frozen soil is currently being prepared for the analysis of microbial communities. At the same time, sub-samples are being stored for analyses of organic compounds.

**Figure 3: Number of CS2000 soil samples received monthly for analysis of microbiology and organics during the 1998 field survey**



*Staff:* A new full-time ASO started work on 16<sup>th</sup> Feb. 1999 to process frozen CS2000 soil cores for microbiological analyses. She has done preliminary tests to determine an inoculation strategy and has started to prepare solutions for BIOLOG analysis and to thaw, sieve and determine moisture contents of one batch of CS2000 soil samples.

*Experimental strategy for sample processing and storage:* Between 80 and 100 samples will be processed during a 2 week period to minimise the time between thawing and inoculation of spread plates and BIOLOG GN microplates. Small batches of 10-15 samples will be processed at each time to standardise the durations of thawing and storing at 4 °C (before re-freezing or before microbiological analysis), as much as possible. Samples will be wet sieved (2 mm mesh), mixed and stored at 4°C in double polythene bags. Moisture contents will be determined at this stage. In the next stage, 5 g dry weight equivalent of each sample will be placed into separate dispersion tubes for spread plate and BIOLOG analyses. The remaining sieved sample will be re-frozen (in double polythene bags) at -20°C for analysis of organic compounds. This storage method has been agreed with Dr. Dan Osborn, ITE Monkswood.

*Data recording:* The CS2000 Access database was used to produce a list of the CS2000 microbial samples received by ITE Merlewood. These were sorted in ascending order of their date of freezing and transferred into Microsoft Excel for ease of use. This Excel spreadsheet is being used to input dates of thawing, sieving and re-freezing of samples; weights of the intact core and sieved sample are also recorded on this. A second spreadsheet has been created to input data for calculation of the soil moisture content and dry weight equivalents.

### **3.8.3 Soil faunal community**

*Staff:* In November 1998, a full-time SO was appointed to the Soil Ecology Section at ITE Merlewood to carry out identification of soil fauna from the CS2000 samples and to carry out data analyses. Two taxonomic training courses to cover order to genera identification of key groups have been organised for April for three staff from ITE Merlewood.

### **3.8.4 Metals, metalloids and organic compounds**

All soil samples have been stored awaiting analyses that will commence in April 1999. A full list of chemicals to be analysed will be identified by the end of March 1999.

### **3.9 Other activities**

A www page was completed for MASQ and has been added to the CS2000 web-pages. An article was also completed for inclusion in the CS2000 web pages (<http://www.cs2000.org.uk>).