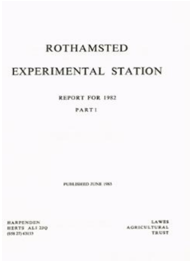
Report for 1982 - Part 1



Soil Survey of England and Wales

D. Mackney

D. Mackney (1983) *Soil Survey of England and Wales ;* Report For 1982 - Part 1, pp 227 - 251 **- DOI: https://doi.org/10.23637/ERADOC-1-129**

SOIL SURVEY OF ENGLAND AND WALES

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https://doi.org/10.23637/ERADOC-1-129

Introduction

After three vigorous years of fieldwork, the National Soil Map at 1:250 000 scale has been completed and will be published in Spring 1983. It represents perhaps the most significant achievement since the formal setting up of The Soil Survey of England and Wales in 1939. Its completion is a result of dedication by all staff to the project. Earlier surveys have been updated and incorporated and credit is thus also extended to many scientists who are not current members of staff. The map was commissioned by MAFF with the primary aim of providing a systematic inventory of the soil resources of the country, capable of being used or interpreted for a wide range of purposes, including advisory work and land use planning. It provides appropriate information at national, regional and county level, and even at farm level will indicate the commonest soil(s) and the pattern of soil variation.

There are six sheets conforming to ADAS regions with some overlap, each regional map having an abbreviated coloured key and inset small scale maps giving sheet boundaries and the locations of earlier surveys. An extended legend covering all six sheets describes the composition, characteristics, land use, and percentage area of the 296 soil associations identified. These have number codes, and are simplified to 67 delineations by colouring according to dominant subgroups. Bulletins describing each of the regional soil maps are in preparation for publication in 1984.

Work has commenced on a National Lowland Peat Inventory, the results of which will bring together data on the thickness, stratigraphy and physical and chemical properties of peat and peat soils. In view of the impermanent nature of organic deposits and their unique place in land use, this information should be used to create a policy for their long term protection and optimum utilization.

A computerized Soil Information System now exists and awaits decisions concerning the new ARC computing facilities and database software, before a 'user-friendly' way of searching, retrieving and manipulating data can be fully operative. Field, laboratory and map unit boundary data are stored, including data from 5000 pits dug as part of the National Soil Inventory. Progress continues with the National Catalogue of Soil Series to provide a complete guide to series and map units in terms of definitive descriptive, analytical and behavioural data. Proposals for a common ADAS/Soil Survey Soil Information System have been presented to MAFF and ARC.

A Soil Survey Research Advisory Committee has been formed to advise the ARC on the policy and programmes of The Soil Survey of England and Wales and The Soil Survey of Scotland. The chairman, Dr G. W. Cooke, was a member of the previous Soil Survey Research Board.

The work of The Survey was exhibited at The Royal Show, Stoneleigh, both in the Science into Practice pavilion and the Soils Centre. The themes were soil texture, its measurement in the laboratory and its significance in agronomy, and soil maps and their uses. The latter exhibit previewed the National Soil Map by presenting a coloured version of the regional soil map for Northern England. Other exhibitions were mounted at Break Crops '82, The Royal Norfolk Show, and the *Farmers Weekly* Drainage Event.

The commitment of staff to the priority tasks of preparing regional maps and bulletins for publication has not interrupted collaboration, consultation and tuition (as appropriate) with ADAS, ARC Institutes, Universities and Colleges, Local Authorities, Water Authorities, Schools and commercial firms.

National map programme

Fieldwork for the 1:250 000 National Soil Map finished in March upon completion of work in the South-west and South-east Regions and East Anglia.

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After checking and editing the 1:25 000 field sheets an outline soil map at 1:50 000 scale was completed, from which the 1:250 000 map was compiled. The map legend lists 296 map units and describes the main soils, their present land use and area. Most map units cover several hundred km² and many occur in several regions.

Preparation of the six bulletins to accompany the regional maps is well advanced, with first drafts of the two main chapters for all the books now being edited; illustrations have been selected and are being drawn. Forty authors are involved and central co-ordination of writing has been needed; much time has been saved by using word processors and the text stored in them will eventually be used directly by the printer to prepare final proofs.

The bulletins include general introductory accounts of climate, relief, geology and land use, a chapter describing the map units in detail and others concerning drainage and the interpretation of the soil map for various uses. A comprehensive reference list is included and an Appendix with selected detailed soil profile descriptions. (Hodgson)

East Anglia

Fieldwork for the 1:250 000 National Soil Map finished in February. In Bedfordshire, Cambridgeshire and Essex revision of the 1:25 000 scale 100 km² sheets within the confines of the previously published reconnaissance soil maps on 1 in. to 1 mile Sheets 147 (Bedford and Luton) and 148 (Saffron Walden) was completed. In these areas 4 to 6 days were spent resurveying each 1:25 000 sheet compared to 9 to 10 days for areas never previously visited by The Survey. Soil boundaries were reinterpreted and revised for publication at 1:250 000 scale. The most obvious change from the previously published reconnaissance maps is the recognition of an area of better drained soils, mainly Stretham series, on Chalky Boulder Clay around the Roding valley north-west of Chelmsford.

During the final period of fieldwork, a number of areas were revisited to check the range of soils occurring and to refine soil association boundaries. Marshland west of King's Lynn, Breckland, parts of East Suffolk, and the Chelmsford, Hatfield and Hemel Hempstead areas were all revisited at this time.

The compilation of the final map involved a reassessment of published detailed soil maps on Sheets 173 (Ely) and 188 (Cambridge) and the surrounding area of Sheet 135 (Cambridge and Ely), areas on which no fieldwork was carried out during the 1:250 000 scale map programme, as well as incorporation of the newly published 1:100 000 Norfolk soil map. (Hodge and Regional Staff)

The Midlands

Fieldwork for the 1:250 000 National Soil Map was completed in March when the 12 remaining 1:25 000 maps in Cheshire and the northern fringes of Derbyshire and Nottinghamshire were finalized. Effort was concentrated in eastern Cheshire, where fieldwork for the Cheshire County map (Furness 1978) had been least intensive. The contents of map separates on the Cheshire County map were checked and reassessed in accordance with the 1:250 000 legend. Most of the lines from the old County survey survive but to retain consistency with adjacent areas some line alterations were inevitable.

Staff in the Midlands are responsible for the authorship of 69 soil associations to be included in bulletins to accompany the National Map. All have now been drafted and are being edited. Chapters and sections on relief, geology, climate, agriculture, forestry, land drainage and agricultural interpretations for the ADAS Midland and Western England Region are in preparation. SSEW Midland Region staff are also writing chapters on land drainage and agricultural interpretations for the East Anglia bulletin.

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Checking line work and map unit symbols for the 1:250 000 scale map and map legend proved to be a long and complicated task. (Ragg and Regional Staff)

Northern England

With fieldwork for the National Soil Map already completed the principal tasks this year have been map compiling, checking map proofs and preparing the explanatory bulletin. R. I. Bradley, however, was seconded to the Midland Region for a month on mapping duties, and the National Soil Inventory sampling was completed in Northumberland.

The recently completed soil series rationalization was used in the compilation of a list of soil profile descriptions suitable for inclusion in regional bulletins. One representative profile description, with appropriate supporting data, has been selected for each soil series in the National Map Legend.

Soil mapping at 1:50 000 was started in two districts. In a reconnaissance of the Alnwick and Rothbury district (Sheet 81), stagnogleys were found to be extensive on, and west of, the coastal plain. Soils of special interest include a sequence of brown podzolic, humic brown podzolic and ferric stagno-podzols on andesite, and stagnogley and humo-ferric podzols on the Fell Sandstone.

In the Wensleydale and Wharfedale district (Sheet 98), rankers, brown earths and stagnopodzols in locally-drived drifts overlying Carboniferous Limestone were encountered at Grassington, with raw peat soils on the high plateaux nearby. (R. A. Jarvis and Regional Staff)

South-east England

Fieldwork for the National Soil Map was completed with the survey of some small areas in south Hampshire and the reappraisal of earlier work in Oxfordshire, Berkshire, Buckinghamshire and Kent. In addition, a further 82 National Soil Inventory points were visited and full descriptions made of 18 selected profiles.

In Buckinghamshire, examination of soil distribution in drift deposits on the Chilterns showed that fine and coarse loamy over clayey paleo-argillic brown earths, identified as the Marlow association, were sufficiently extensive to be separated from similar fine silty over clayey soils of the Batcombe association. Soils in gravelly Plateau Drift near Beaconsfield have been grouped into two associations: paleo-argillic brown earths of the Sonning series were dominant in both, but where gravel was over permeable Chalk or Reading Beds, Bockmer and St Albans series (brown sands) were principal associates, whereas in areas with clayey substrates, Berkhamsted and Wickham series (stagnogley soils) were common.

In east Berkshire, further fieldwork showed that the land formerly designated Map Unit 12 could be divided between Holidays Hill (gley-podzols) and Fyfield (argillic brown earths) associations, with Swanwick (argillic gley soils) association occupying the larger valleys.

The coastal marshlands of north Kent have been mapped as Wallasea (alluvial gley soils) association but a thin humic topsoil phase (previously identified as Downholland series) was widespread on old undrained grassland. On the Hoo peninsula, land with thick drift over London Clay has been assigned to the Ratsborough association, comprising loamy over clayey argillic brown earths and stagnogley soils. In the west of the county, areas of Kent Map Unit 63 have been separated as Fyfield association, because coarse loamy argillic brown earths (Fyfield series) are dominant, though elsewhere the land is in Hamble association. (M. G. Jarvis and Regional Staff)

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South-west England

Fieldwork for the National Soil Map continued around Gloucester and Cirencester, where recognition of soil patterns on Jurassic formations was completed. On Lower Lias clay in the Vale of Gloucester calcareous pelosols predominate with brown calcareous earths in patches of limestone drift. On parts of the Cotswolds scarp, Middle and Upper Lias silty shales and clays form narrow strips of fine silty over clayey typical stagnogley soils and stagnogleyic argillic brown earths, often on landslipped ground. On the Cotswolds dipslope, fine loamy and clayey brown rendzinas and brown calcareous earths predominate with fine loamy brown earths and argillic brown earths represented, especially over the Forest Marble formation. Narrow bands of clay give rise to calcareous pelosols, some with associated shallower soils on thin limestones.

Additional representative profiles were sampled to complete fieldwork for the National Soil Map and this was followed by compilation at 1:50 000 scale of all accumulated field data. The remainder of the year has been given mainly to writing soil association (map unit) descriptions, each surveyor being responsible for a proportion of the national legend of units. In addition staff have been made responsible for a number of other chapters or sections of the bulletin and these have been brought to various stages of completion:

(a) Identification keys for all the national soil associations were revised and recast in a standard form.

(b) A map showing growing season has been derived from data in *MAFF Technical Bulletin* No. 34 to illustrate the account of climate to be included in the Regional bulletin.

(c) Data on forestry in the region has been accumulated by relating Compartment Schedules and Stock maps to soil maps as a basis for yield class assessments for common tree species on main soil types.

(d) A Land Use column was prepared for the National Map Legend which includes entries such as crop type, grazing quality in uplands, habitat types for semi-natural vegetation, and land use other than agriculture, e.g. recreational, military, and gravel or peat working.

Initial reconnaissance of Sheet ST 41/51 (South Petherton/Yeovil) was started to identify map units on Jurassic sands, clays and limestones and associated drifts. Intensive agriculture has led to some erosion in recent years on the Yeovil sand where soils have a high very fine sand or silt content and mostly are coarse silty typical brown earths (South Petherton series) or fine silty stagnogleyic argillic brown earths (Curtisden series). Colluvial soils appear to be widespread but their identification is difficult in the field. (Findlay and Regional Staff)

Wales

About 1000 km^2 were examined in north Cheshire to incorporate previous work (Furness 1978) into the National Soil Map. Much of the landscape is covered by reddish drift from Triassic sediments. Stagnogley soils (Salop and Clifton series) occupy the till-covered lowland with brown sands (Newport series) and brown earths (Wick series) in glaciofluvial drift. Brown sands (Bridgnorth series), brown earths (Bromsgrove series) and humo-ferric podzols (Delamere series) were mapped on the more hilly land with sandstone bedrock, while pelo-alluvial gley soils (Compton series) and eutro-amorphous earthy peat soils (Adventurers series) were found on valley floors. Humic alluvial gley soils (Downholland series) and calcareous alluvial gley soils (Agney series) fringe the Mersey.

Descriptions of map units and sections on geology, relief, climate and agriculture have

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been written for circulation and comment and other sections are currently being compiled; illustrations have been submitted and photographs selected. (Rudeforth and Regional Staff)

The Soil Survey Information System

One of the primary aims of the Soil Survey is the observation, collection and organization of soil data in three dimensions. By the mid-1970s data manipulation by traditional methods had become so labour intensive and time consuming that individual analyses or profile descriptions could not be synthesized on a regional or national basis. The only way out of these difficulties was to set up a computer-aided data management system.

The first steps towards a comprehensive Information System for the Soil Survey were taken in 1977 when all detailed profile descriptions and analytical data were recorded on computer-compatible forms. Even then, however, the secured data could only be used as single records and manipulation or interrogation of datasets was not possible. The design of a comprehensive Soil Information System commenced in 1979 with a detailed description of its functions and the design of 'user-friendly' field recording forms. The functions of the system were specified without regard to the computing facilities then available within the ARS and it is encouraging that current ARS investment in both hardware and software has made these early plans feasible. The main functions are summarized:

1. Efficient handling of large volumes of many types of data (see Fig. 1).
2. Validation and correction of data.
3. Updating facility for new information or modifications.
4. 'User-friendly' retrieval of data, depending on values of and relationships between any attributes held in the system.
5. Interfacing with other software, e.g. GENSTAT.
6. Production of output in the form of reports, tabulations, statistical summaries and graphics, including maps.

To the user the system will appear similar to the schematic layout in Fig. 1. The user will require a knowledge of the files within the system, their relationships and the fields held within them, but the array of database management (DBMS) and in-house software should be transparent. The system as seen by the systems analyst/programmer is in three parts shown in Fig. 2. When the overall system was designed account had to be taken of the following:

(i) Within 3–4 years the ARS computing facilities would change;
(ii) The database management system would be determined at the same time;
(iii) Large volumes of data were currently being collected and some data processing was required immediately.

The first stage of the system, primarily concerned with validation, conversion, cross-checking, error reporting and correction, updates master files from which data can be retrieved by *ad hoc* programs. This stage, programmed by our own staff, allows for great flexibility in the checking of information. It is envisaged that the second stage will be the provision of a new database management system and the third stage will consist of software to interface retrieved data with other software where this is necessary.

The first stage of the system is complete and data for the various files of the information system are being processed. Some decisions on database structure await knowledge of the software that will be available to the Soil Survey from the ARS Computing Service.

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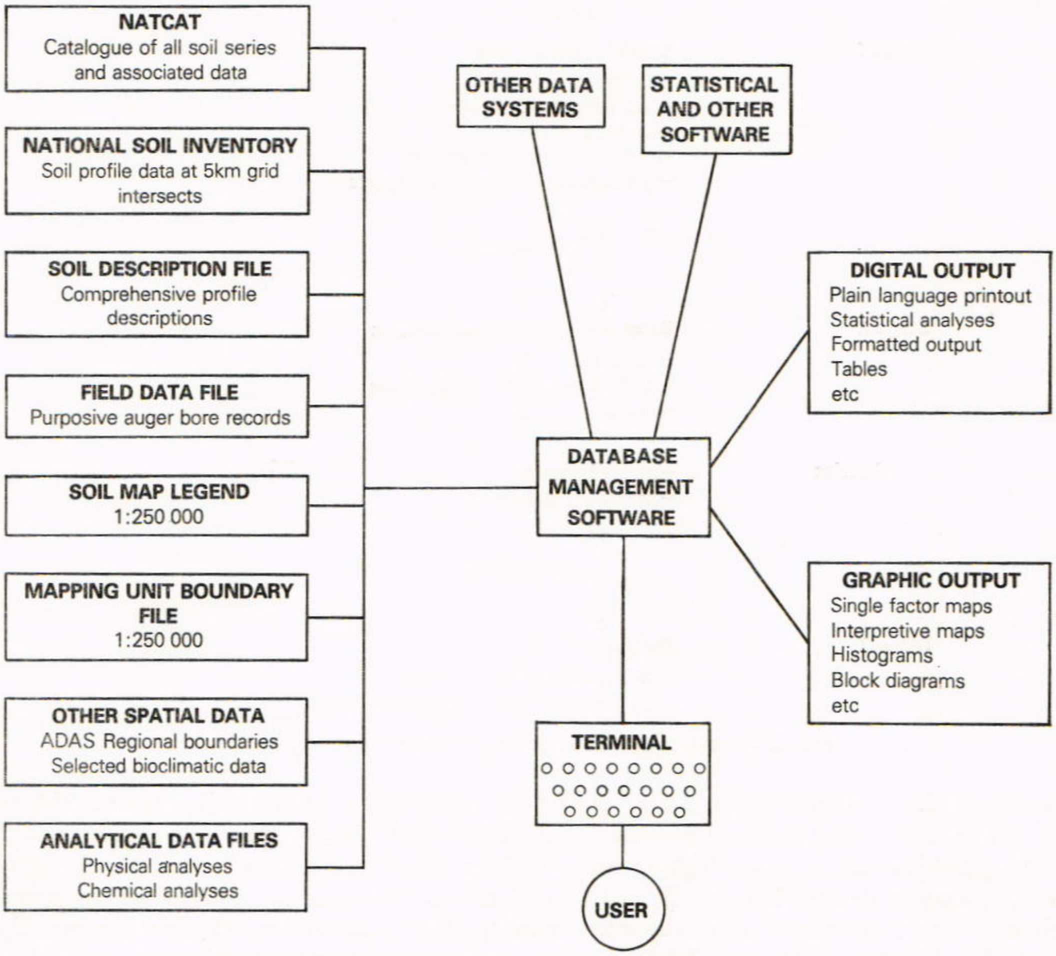

FIG. 1. A User's View of the Soil Survey Information System.

However, in-house programs have been written in such a way that it should be a simple operation to input the 'clean' data to the second stage—a data management system.

Shortly after new hardware has been installed at Rothamsted Experimental Station and at the ARS Computing Centre it is expected that all our data and software will be transferred to a new machine. After this transfer period a Soil Survey Information Service can be provided—either direct from a terminal or via a data controller. The initial level of service will depend of course on the files mounted and software available, but it will be possible to use the system while it is further developed.

The main users of the Information System will be soil surveyors and headquarters staff, the former requiring the manipulation of Regional subsets of National databases while the latter will be more likely to require answers from nation-wide databases. Some staff will have the opportunity to use the system via a direct line, the British Telecom package switching service (PSS) or dial-up terminals, while others will prefer to receive service from a data controller. It is also envisaged that outside users will require a service and perhaps eventually use direct access.

Staff consulted about the design of the system have been able to identify many types of user requirement and many examples of likely interrogation, some of which are given below. Most of these are of an *ad hoc* nature and only a few regular type queries are

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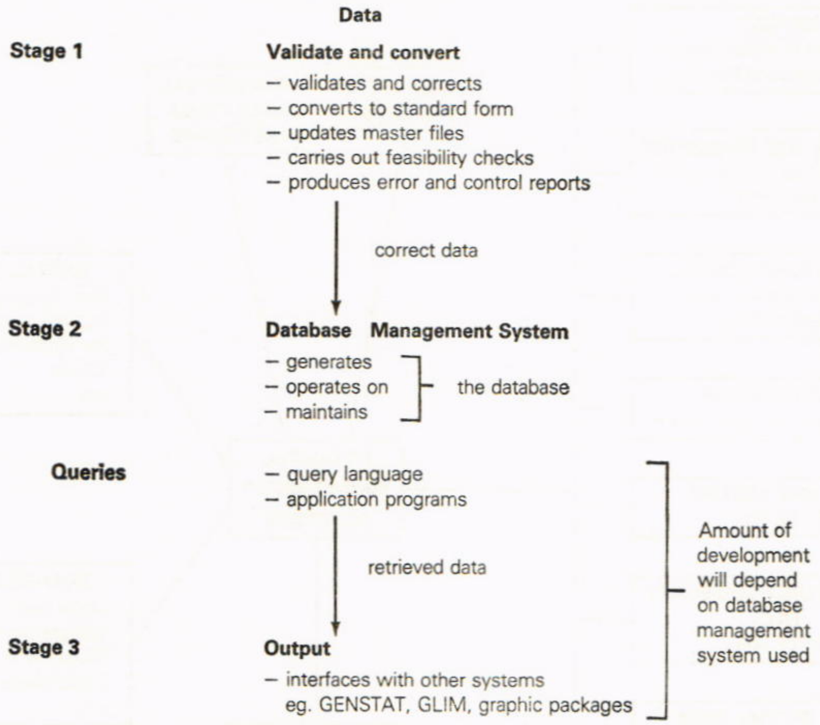

FIG. 2. Overall View of the Soil Survey Information System.

anticipated. Soil surveyors (and the Soil Survey's customers) have a well proven tradition of using maps for graphical representation and spatial interpretation so an interface with graphics software is a high priority, but the simulation of traditional cartography on flat-bed or drum plotters will not be considered for some time. Grid cell mapping from a raster storage of soil map units is being developed at present. For the recently completed National Map (1:250 000) storage of the 296 mapping units will be held in the form of 0·5 × 0·5 km square rasters related to the National Grid and will generate some 700 000 cells when the whole of England and Wales is digitized. This large spatial database will be manipulated and mapped by the recently acquired AREAS program and generate shaded maps on a daisy-wheel or matrix printer as shown in Fig. 3. Maps of this kind are cheap to produce, and ideal for the initial appreciation of spatial representations. Matrix printer output is usually also of a sufficiently high quality to be reproduced in Soil Survey publications or scientific papers if the shadings are selected with care. Unlike conventional maps, this kind of graphical output lacks geographical detail but this can be provided photographically when the need arises in the form of a transparent overlay.

The potential for interrogation of the Soil Survey Information System is large and queries have already been processed using unvalidated data. As stated above, most interrogations are expected to be of an *ad hoc* nature and a sample selection is given below.

(i) Display the distribution in Ordnance Survey square NY of all soil associations with more than 50% stagnogley or gley soils (dark) and stagnogleyic or gleyic soils (light) where the mean potential soil moisture deficit exceeds 100 mm.

(ii) List all soil series identified on Sheet No. SP 22.

(iii) Plot all occurrences of Ashley, Hanslope, Hall and Freckenham series (+) and Needham and Wyre series (.) on Sheet No. TM 38.

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(iv) Calculate regressions for Atterberg liquid and plastic limits *v* % clay, % silt and % carbon for all soil horizons held in the information system with all five analyses.
(v) Calculate the correlation coefficient for Munsell chroma of all Bs horizons with pyrophosphate-extractable iron.

Plans for the Information System extend beyond the use of a main-frame computer and an embryo Regional Office system is already under development on a microcomputer at the Shardlow centre. This machine is well able to handle subsets of National databases as well as local data and has already proved to be of great value in the day-to-day handling of lists, catalogues and brief textual material. Subsets of files of comprehensive soil descriptions have already been transferred to this work-station and are providing an insight into how the Soil Survey should develop a distributed Information System.

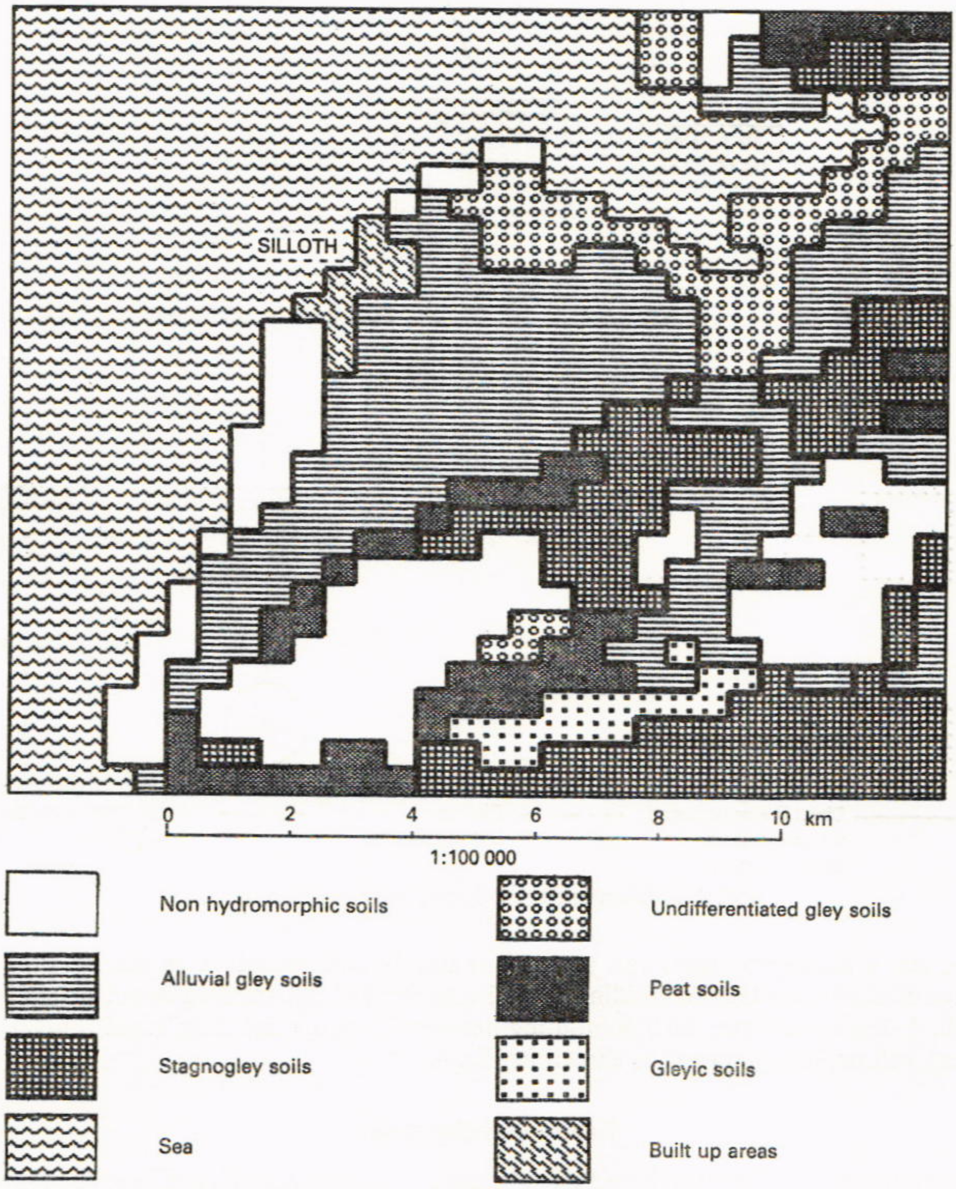

FIG. 3. Groupings of Soil Subgroups by Gley Morphology.

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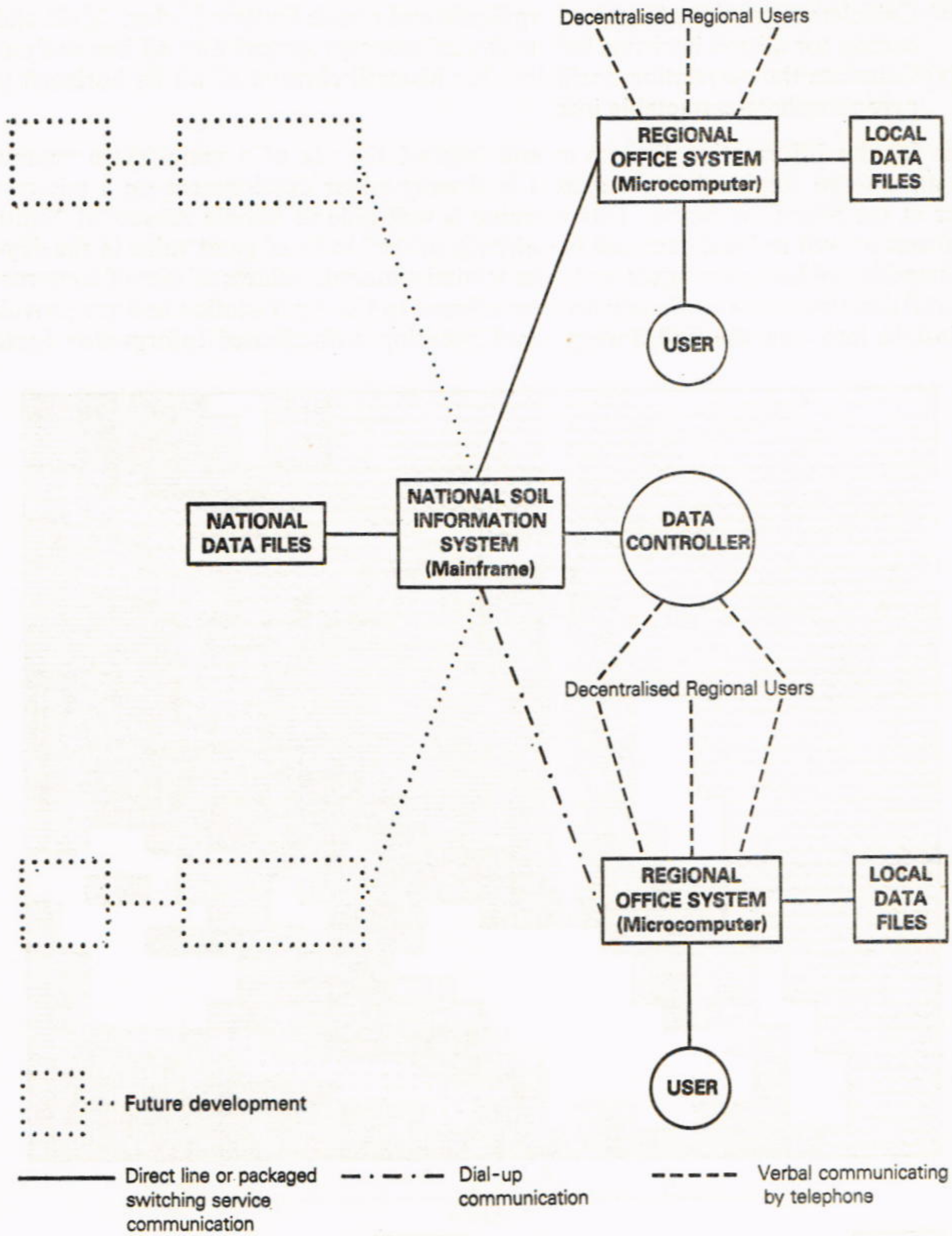

FIG. 4. A Distributed Soil Survey Information System.

These small microprocessors can be used as stand-alone machines as described above, receive data on flexible disks holding up to 1 megabyte of information or act as intelligent terminals linked into the ARS computing network. A proposed distributed Information System will probably appear as shown in Fig. 4.

Land suitability studies

A methodology combining soil and climatic data to assess suitability of land for common arable crops is being developed to extend the usefulness of the National 1:250 000 Soil

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Maps and the accompanying Regional Bulletins. It is proposed to describe relative suitability for winter cereals, spring barley, winter oilseed rape, potatoes and sugar beet in four classes. A system to determine suitability of land for use as intensive grassland is already published (Jarvis and Mackney, 1979; Harrod and Thomasson, 1980).

The methodology to assess land suitability is grounded on soil properties that are regularly observed during soil surveys, such as texture class, structure and depth. These can be expressed in terms of the very large stock of physical data now stored in the computer, for example water retention and porosity measurements (Hall *et al.*, 1977). Data on field soil water regimes involving duration of waterlogging and depth of drying by crop extraction are also available, but are less easily accessed, because many different organizations hold the information.

A climatic data set with resolution to 10 × 10 km has been assembled. The chosen climatic parameters are:

1. Accumulated temperature above base 5·6°C (whole year) and above 0° (January to June) in day °C.
2. Potential soil moisture deficit adjusted for specific crop growth periods (mm).
3. Field capacity days, defining the calendar period when meteorological soil moisture deficits are effectively zero.

Commonly in hill areas, excessive rainfall, expressed by a long period of field capacity or small soil moisture deficits, and locally, low temperature, form severe limitations for crop production. These limitations are effective even where soil and slope conditions are acceptable. In the lowlands the degree of suitability for a particular crop involves mainly interactions between crop water supply (drought stress) and opportunity to establish and harvest the crop under good conditions. Crop water supply is a balance between soil water reserves, within the depth of soil exploitable by the crop, and the atmospheric 'demands' expressed as potential soil moisture deficit (Jarvis and Mackney, 1979). Opportunity for land work, in physical terms, varies with the wetness of the climate, soil permeability and soil water retention properties during critical periods of the year for the particular crop. These land attributes are brought together into one term 'potential machinery work days' (Thomasson, 1982; Smith, 1977).

High suitability of land for a given crop combines a low risk of drought and ample opportunity to establish and to harvest the crop at optimum dates with low risk of soil damage. Low suitability may be caused by excessive drought risk and/or difficulties in establishment or harvesting which interfere with sustained production. Much land has defects for both drought and for crop establishment. The criteria obviously differ for autumn- and spring-sown crops and for combinable as against root-harvested crops.

Mean climatic parameters mainly change gradually from place to place and are mappable at 1:1M or 1:500 000 scale. The soil components of suitability, however, change more sharply and may not be precisely resolvable at scales smaller than 1:50 000. For this reason assessments of crop suitability will be based primarily on the soil series and will initially be presented in tabular rather than cartographic form. The soil map will later be used to construct suitability maps for specific crops, based on the lead soil series within composite map units. The degree of reliability of such maps will vary with map scale. For greater precision at farm level more detailed soil maps (1:50 000 or 1:25 000 scale) will be necessary. The methodology being developed is sufficiently sensitive to be used at field level. (Thomasson)

National Peat Inventory

A survey of peat soils in the Somerset Moors reported in 1979 was followed in 1982 by

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publication of a 1:50 000 map showing the thickness of peat to mineral substratum at each of 300 sampling points on a grid of 1 × 0·5 km spacing; peat thickness between 2 and 8 m is shown by colour tints. Two sketch maps at smaller scale indicate the types of peat within 1·5 m of the surface and, where present, the thickness of clay overlying the peat.

A survey of peat and alluvium in four Norfolk river valleys was noted in the *Report for 1981* and similar work has been published for the Stilton district of the Cambridgeshire Fens (Burton and Seale, 1981). In both these East Anglian districts there is evidence of pronounced acidification caused by oxidation of iron sulphide (pyrite) and acid sulphate soils are likely to become more commonplace as drainage and wastage of peat proceeds.

With these indications as background, proposals for a National Inventory of Peats were submitted to MAFF and it was agreed that all the main areas of lowland peat in England and Wales should be sampled. As in the earlier investigations the main intention is to determine the present pH of peats and to assess their potential for change by a second measurement following 3 months storage. In addition, opportunity will be taken to record as much data as possible on properties of the peat deposits and on the character of soil layers developed in them.

In view of other staff commitments it has not been possible to make a full-scale start on this project but following a September training session held in Cambridge three teams have commenced field survey in Somerset, the Fens and the Norfolk/Suffolk valleys. This initial work to test criteria used and to assess field methods and organization has also established a routine with two ADAS regional laboratories, where pH determinations are run in weekly batches.

Grid surveys, in this case at sampling intervals of 0·5 km, present certain problems concerning access, particularly when seeking permission in districts like Somerset where land ownership is fragmented. Movement from site to site can also be very time consuming when long detours are necessary and daily progress is controlled more by these considerations than by any other factor, though poor weather and ground conditions contribute; progress varies from three sites per day in difficult situations to eight or more on large arable farms.

Auger borings are made with 30 mm diameter gouge augers which are quick and effective in deep peat, though the Edelman auger head is better in drier upper layers and gives a larger sample for thin layers. Samples for first pH are bagged quickly to exclude as much air as possible whilst second samples for pH after 3 months are stored in open bags under cover and maintained moist; this procedure simulates the effects of drainage and oxidation under field conditions.

The following field data are recorded on (RUFF) cards modified for the peat inventory from standard cards used in routine soil surveys.

(a) *Botanical composition*. This is the most common basis for characterizing stratigraphical units in peats, though a relatively small proportion of deposits include recognizable fossil plants. A system devised by Troels-Smith (1955), widely used in botanical circles for describing unconsolidated deposits and recommended by Professor R. G. West (Cambridge), is being tested.

(b) *Humification*. Von Post criteria are used for all layers to which they can be applied.

(c) *Fibre content*. This is assessed on a scale (as fibrous, semi-fibrous and amorphous) and the proportion of fibres present in the natural state and after rubbing is also estimated. This assessment is currently the equivalent of particle-size assessment in mineral soils and is still controversial.

(d) *Colour, presence of carbonates and other mineral deposits*. A separate decision is made on the character of the surface horizon, i.e. earthy or raw, and integration

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of this with pH and fibre contents within the control section (1·5 m depth) leads to the subgroup designation of the peat soil.

(e) *Site data.* These will provide a pool of information on present land use, which ranges widely from semi-natural marsh to arable and intensive horticulture. Where appropriate, vegetation will be recorded in broad community classes compatible with conservation interests.

A remaining major difficulty in this survey concerns the large areas that have been or are currently being much altered by peat extraction, leaving a mosaic of highly modified peat profiles and exposed mineral substrata. In Somerset, sampling on the extensively cut-over Westhay and Shapwick Heaths has established that virtually no moss peat remains; thin layers of cotton grass peat are all that is left of the former raised bog and very little of this has pH values less than 4·0 within 1·5 m depth. Eighty sites were sampled on this cut-over area and in Kings Sedgemoor on well-humified fen peats, where all pH values were above 4·0.

Fenland sampling in October and November (150 sites covering 38 km^2) confirmed that acid sulphate soils (Mendham and Prickwillow series) are concentrated in the marginal zone of the marine Fen Clay deposit; pH values below 4·0 were recorded in ripened Fen Clay, in peat overlying and underlying such clay, and in sandy substrata (pH as low as 2·2), and can occur at all sampling depths down to 100 cm, but not in the undrained layers below. These results demonstrate changes undergone by wastage of peats formerly mapped in the Cambridge and Ely districts between 1955 and 1970.

Sampling at 120 sites in five Suffolk river valleys and adjacent coastal marshes proved 1 to 6 m of mainly sedge and woody peat.

The final results of this survey will bring together for the first time much useful data on the extent, thickness, stratigraphy, and physical and chemical properties of peats and peat soils in England and Wales. In view of the impermanent nature of organic deposits and their unique place in land use this information should be used to create a policy for their long term protection and (best) utilization. (Findlay, Burton, Cope and Corbett)

Basic research

Quantification of pore patterns. Pore patterns in a range of soils have been studied. Images of the patterns are obtained by photographing in UV light the faces of impregnated blocks of soil to which a dye has been added. A system has been developed to enable the image analysing computer (Quantimet) to recognize in these images various functional pore types and to output pore-size distributions and proportions of the total porosity occupied by each pore type. The system was developed by 'teaching' the computer with samples of pore types, so that a statistical comparison could be made between any pore and the 'learning set' using several shape factors. The system is semi-interactive, requiring the operator to confirm borderline cases.

Measurements made should be interpretable in three dimensions. The project will continue by identifying the range of the main structural types and examining the way in which they relate with other physical properties. It is hoped to input quantitative measures of structure into models of water movement. (Ringrose-Voase, Bullock and Murphy)

Soil microstructure and its relationship to water movement. A project has been undertaken jointly with the Forestry Commission and the Institute of Terrestrial Ecology to characterize the physical properties of soils on an experimental site in Beddgelert Forest. The experiment was set up to examine the effects of management practice, in particular clear felling, on the physical properties of the soils. From each of the four blocks of the experiment, four profiles have been described and sampled for basic chemical and

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physical analyses. Large Kubiena tin samples (20 × 13 × 4 cm) were taken from each soil horizon and resin impregnated. Pore-size distributions and various other pore characteristics such as shape, orientation and 'nearest neighbour', are being determined using the image analysing computer.

The experiment is sited on steep slopes, and water moves through the soil both vertically and laterally. Pore space suitable for transmission of water in five of the principal soil types is being investigated by infiltrating dyes. Five lysimeters, one 75 × 45 × 45 cm, the other four 70 × 40 × 35 cm, were excavated and transported to the laboratory. Infiltration rates and saturated hydraulic conductivity were first measured in the vertical direction. Following measurements of hydraulic conductivity, methylene blue was passed through the profiles to determine the main vertical pathways of flow. The lysimeters were then placed on their sides to measure horizontal infiltration rates and saturated hydraulic conductivity. A different coloured dye, Rhodamine B was passed through to establish the main horizontal pathways of flow. Vertical and horizontal thin sections are being made to establish the pathways taken by the dyes and to relate proportions of dyed voids to infiltration and hydraulic conductivity measurements. (Dr C. Nys, Centre National de Recherches Forestières, Nancy, France, and Bullock)

Methodological research

Pyrophosphate extraction of Fe and Al. Amounts of Fe and Al extracted from soils by 0·1M solutions of K-pyrophosphate (Bascomb, 1968) or Na-pyrophosphate (Soil Survey Staff, 1972; Canada Soil Survey Committee, 1976) are widely used in pedological studies and soil classification. It seems to be generally assumed that differences in procedures give rise to insignificant differences in the amounts of Fe and Al extracted (Sheldrick & McKeague, 1975). The precision of three such methods has been tested by analysing six replicates of each of seven soils covering a range of extractable Fe and Al contents:

(a) USA: Na-pyrophosphate solution at pH 10 followed by extract clarification with Superfloc (an organic flocculating agent) at low centrifugation speed (Relative Centrifugal Force 415).
(b) Canada: Na-pyrophosphate solution at pH 10 followed by extract clarification by high speed centrifugation (RCF 20 000).
(c) England and Wales: K-pyrophosphate solution at pH 10 followed by extract clarification at low centrifugation speed (RCF 415).

All clarification procedures were tested on extracts obtained with Na-pyrophosphate at pH 9·6.

Conclusions are:

1. All methods give a wide spread of values for Fe and Al for all the soils, i.e. precision is poor. Coefficients of variation ranged from 2 to 25% for Fe, and 5 to 38% for Al; the methods giving the lowest coefficients for Fe are not, however, those giving the lowest coefficients for Al.
2. No one method is superior to the others in all respects for both metals, but the Canadian method is most precise for Al and only marginally inferior in terms of precision for Fe.

The Canadian method seems best on analytical grounds, but it tends to give lower values for Fe and Al contents than the other two methods. This would create difficulties for organizations changing to the Canadian method as it would affect the limits of the values of extractable Fe or Al used as defining criteria in soil classification. The investi-

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gation emphasizes the urgent need for international agreement in methods of soil analysis. (Loveland, Williams and P. Digby, Statistics Dept)

Data management. The three parts of a system for the validation and conversion, cross checking and updating, error reporting and correcting of many kinds of soil survey data are now completed. Approximately 70 000 purposive and 5000 National Soil Inventory (NSI) records have been entered into the computer via this system and secured on magnetic tape. Some 3000 purposive and 4000 NSI records have been processed through the cross-checking system. Clerical and data security procedures have been designed and implemented to cope with the despatch and receipt of these records.

Map unit boundaries at 1:50 000 scale have been raster digitized for the National Grid 100 km squares NT, NU, NX, NY, NZ—approximately 10% of England and Wales. This database, representing approximately 60 000 0·5×0·5 km cells, has been set up on the Prime using the software package AREAS. A map of this area has been printed and is being checked.

A regular service to keep online files of laboratory records and comprehensive profile descriptions has continued. Laboratory information and site information for approximately 1300 and 1800 sites respectively are now online and many requests for extracts have been satisfied. Information from these files has been extracted and passed to the word processing system successfully via the Prime and Superbrain microcomputer.

A Microfin hand-held data logger has been purchased and some initial tests carried out. A comprehensive program is being written to collect purposive records in preparation for a field trial early in 1983.

Work has commenced on the development of a work-station on a Midas microcomputer for use in Regional Offices. Interpreter BASIC and FORTRAN and PASCAL compilers provide high-level programming but most of the work to date has been with the d-BASE II database management system. This system has proved to be very efficient in the manipulation of multi-field alpha-numeric catalogues of soils, soil map units and their associated properties and for handling and updating office files which are subject to periodic change. It has also been used successfully for text file handling using key-words for retrieval. Subsets of National databases have been transferred from System 4 to the Midas and converted to d-BASE format. The ability to transfer data in the reverse direction has also been proven. The d-BASE system has been found to be suitable for use by the non-programming scientist after a minimal amount of training but can also be used as a high-level language. Several programs have been written in d-BASE for data entry and validation and to provide a specialized user service.

Median and quartile dates for return to and end of field capacity, and its duration in days have now been calculated from the data given by Smith and Trafford (1976), for each of the 1737 10×10 km national grid squares in England and Wales. The resulting dataset has been prepared for use by SSEW staff in making soil workability assessments for 1:250 000 map units and is currently stored on System 4. Maps have been prepared using the CAMGRID and SURFACE II programs. Work is in hand to resolve this dataset down to a 5×5 km grid so that it will be compatible with NSI data.

In addition, mean monthly potential soil moisture deficits (1961–75) have been calculated for 954 stations in England and Wales using rainfall totals and estimates of potential evaporation supplied by the Meteorological Office. The evaporation data were corrected for altitude and the potential deficits for grass were adjusted for different crops (cereals, potatoes and sugar beet). The dataset is based on over 40 000 monthly moisture balances and is also stored on System 4. Contour maps have been drawn using SURFACE II and these will form the basis for climatic maps to be published in the new series of Soil Survey bulletins. Available water contents have also been calculated for about 650 soil profiles from water retention measurements made at Shardlow over the past 10 years and these are currently being used in conjunction with soil moisture deficits to assess droughtiness for 1:250 000 soil map units. Ultimately all these data will be included in the information system. (Ragg, Proctor and Jones)

Applications research

European SAR 580 project. All optically and digitally derived radar imagery for this project (*Rothamsted Report for 1981*, Part 1, 223) has now been received. The digital images are of lower quality than the optical images, and band c images are inferior to those of band x. The digital images are still being processed by the Royal Aircraft Establishment, Farnborough, to overcome the fall-off in quality at both edges of the radar swath, and designed to increase its useable width.

Final conclusions on the applicability of radar imagery to soil survey are impossible until digital and ground data have been correlated, but comparison of ground data with optical images in c and x bands suggests that useful applications may be limited. Soils of similar moisture content are imaged differently by radar if surface roughness or crop cover and height vary, so that to record differences in surface soil moisture content the ground must be bare of vegetation and soils must have comparable surface roughness.

Soil erosion. Aerial photographs to record water erosion were taken of 15 of the 16 selected localities. Eight were flown in early May, probably the best time for recording erosion, and the rest in early July. Fieldwork was undertaken to check photographic evidence of recent erosion; volumes of soil moved were determined either by measuring the cross-sectional area at points along rills or gullies, or depths of sediment at a number of points, relating these to lengths of rills or areas of deposition evident either on the photographs or on the ground.

Two hundred and ninety-seven fields were visited of which 148 (49·8%) were eroded. So far, results have been calculated for three localities—sandy soils near Bridgnorth, Shropshire; coarse loamy and silty soils near Yeovil, Somerset; and clayey soils in Cambridgeshire/Bedfordshire.

TABLE 1

Crops (%) in eroded fields

	Shropshire	Somerset	Cambs/Beds
Winter Cereals	41	87·5	88
Spring Cereals	9	—	6
Potatoes	9	—	—
Ley grass	9	—	—
Sugar beet	4·5	—	—
Market gardening	4·5	—	—
Other	23	12·5	6

The preponderance of erosion in cereals, especially winter cereals, is striking. Only in Shropshire was there much erosion in the summer, and then volumes of soil moved were greater than in winter.

TABLE 2

Rates of Erosion (m^3 ha^{-1} y^{-1})

	Shropshire	Somerset	Cambs/Beds
Mean	11·3	18·2	1·1
Range	2·0–36·8	3·8–32·0	0·1–2·5
No. of fields	8	7	19

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Although rates of erosion of clayey soils are low they are equivalent to a surface lowering of 0·1 mm ha^{-1} y^{-1}, which is probably larger than the rate of soil formation. Erosion exceeds deposition in fields where volumes of soil eroded and deposited can be compared, implying a loss of soil from fields into ditches and streams.

Erosion is not always recognizable on 1:10 000 scale aerial photographs, either because rills are too small (<0·2–0·3 m in width) or because depositional fans are obscured by vegetation. Evidence suggests that rates of erosion as high as 20–30 m^3 ha^{-1} y^{-1} can be missed. Also, in some localities, especially Shropshire, erosion occurred between the time of photography and the field visit. Hence, although aerial photography provides an effective way of monitoring water erosion, in some places the pictures should be taken both in late spring and mid-summer. (Evans)

National Soil Inventory (NSI) pilot study. In this systematic sampling study more than 760 NSI profile descriptions for Wales were checked and allocated to soil series as currently defined. Selected information from each profile was coded and a computer used to match them with units on the National Soil Map to estimate map unit content For the most extensive map units in Wales *viz*: Manod (20%), Denbigh (10%), Cegin (8%), Hafren (6%), Milford (5%), Brickfield (5%) and Wilcocks (4%), leading soil series occupy 24 to 46%, and grouped with essentially similar soils these values are increased significantly. At soil sub-group level the legend statement of map unit contents often accounts for between 70 and 80% of the soils present although a smaller percentage is found in some hill and mountain units. The less extensive constituents of the map units as well as the major components will be identified in diagnostic keys in the bulletins to accompany National Map sheets. (Rudeforth)

Euro-Carto I group. The Soil Survey of England and Wales was represented in this group which is investigating digital cartography in Europe. National Map field sheets and fair copies at 1:50 000 scale of the Dolgellau area were digitized in an experiment to show how a potential vegetation map could be prepared from a soil map. (Hartnup and Rudeforth)

Supporting work

Soil micromorphology. Seven hundred and twenty-five thin sections have been made, mostly to aid characterization of soils in the 1:250 000 mapping programme; others relate to various research projects.

In order to increase the representativeness of samples, particularly for the measurement of microstructure, the size of Kubiena tin samples has been increased to 20×13×4 cm. Samples of this size from a wide range of particle-size classes have impregnated successfully. (Bullock, Murphy and Waller)

Soil water regime. Dipwells in Upper Greensand soils near Selborne and Petersfield in Hampshire, and in Wealden soils near Frant in East Sussex were monitored to assess soil wetness class. (Moffat and Sturdy)

In parallel with mapping on the Yeovil Sands, the extent and distribution of erosion is being recorded and dipwells installed to monitor soil water regimes. (Staines and Colborne)

National catalogue of soils. The compilation of text entries for a national catalogue of soils (NATCAT) has commenced. Files giving class definition and history, typical profile descriptions and a listing of profiles on the DECODE database, together with a list of map unit occurrences are in preparation. (Page and Jarvis)

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Special and contract surveys

Work for ADAS. An investigation is being carried out jointly by ADAS, ICI and ARC to examine the performance of winter barley at a number of levels of application of nitrogen on different soils in the north Cotswolds. The first year's results indicate distinct differences between the soils, with better performance on Evesham than on Elmton series. (Findlay)

Soil profiles were described at four sites on the north Kent marshes, where problems, involving clay dispersion, reduced infiltration and the ineffectiveness of drainage, leading to crop losses, are being investigated by ADAS Land and Water Service and the Field Drainage Experimental Unit. (Sturdy and Bullock)

Suitable sites were located in Kent for the measurement of hydraulic conductivity in Fladbury, Newchurch and Wallasea series by ADAS Land and Water Service. (Sturdy)

The soils at an ADAS Land and Water Service experimental site in Weald Clay on the Isle of Wight were described and sampled. (Jarvis)

A report was prepared on the soils of areas where ADAS is monitoring rabbit populations in southern England. Further work on methods and soil mapping of sites for a national rabbit survey was discussed. (Allen)

New detailed soil surveys have been made of Drayton, and High Mowthorpe Experimental Husbandry Farms. (Whitfield, Beard and Furness)

Representative farms in the Radnor Study area have been surveyed to illustrate patterns within the main National Soil Map Units as part of an EEC sponsored study by the Rural Planning Research Trust. (Hartnup, Lea and Rudeforth)

A detailed Soil Map of Cwmfaerdy Farm, Llanddewi Ystradfenny, Powys was prepared for exhibition at an ADAS demonstration on hill land use. (Hartnup)

Work for ARC. The soils at six experimental orchard sites were identified for East Malling Research Station. (Sturdy, Fordham, Hazelden and Jarvis)

Evaluation of experimental site uniformity by examination of soil cores and description of soils at potential experimental sites was undertaken for the Letcombe Laboratory. (Jarvis)

A small area (0·1 km^2) of Lower Burston Farm, Aston Abbots, Bucks was re-surveyed for the Grassland Research Institute. (Fordham)

Other work. A survey for *Farmers Weekly* was carried out at Curworthy Farm, Inwardleigh, Okehampton, Devon which covers 140 ha on two ridges over Carboniferous shales. (Harrod)

A number of fields were surveyed in west Cornwall for Walkers Crisps Ltd of Leicester to help in a study of the agronomy of Record potatoes. (Staines)

Three chalkland farms in north Hampshire (8·3 km^2) were surveyed under contract to Hampshire Arable Systems Ltd. Maps and reports are in preparation. (Allen, Fordham, Moffat and Jarvis)

Data on the soils of the Cuckmere valley in East Sussex were provided for the Institute of Archaeology, University of London. (Hazelden)

A typical example of Wick series was excavated, described and sampled at the RASE cultivation and compaction demonstration at the Royal Show Ground, Stoneleigh. Bulk density samples taken from each of the plots showed meaningful differences. (Beard and Whitfield)

Following the contract survey of 3600 ha in the Tern Valley, Shropshire (1981), a 51-page report was prepared for Lawrence Gould Associates in conjunction with the

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Severn Trent Water Authority, describing the soil types and soil water relationships. (Hollis)

At the request of the Forestry Commission, soil sampling with reference to reservoir silting was undertaken near Hebden Bridge and Holme, West Yorkshire, to assess the stability of clay minerals in high rainfall areas after deep ploughing. (Carroll)

Advice to the British Gas Corporation Engineering Research Station concerned the most suitable locations for proposed research into the radar sensing of objects buried in peat. (Carroll and Bradley)

A soil survey was undertaken, and present and potential land capability assessed in collaboration with ADAS, for the Mainsforth Stell drainage scheme (Co. Durham) proposed by the Northumbrian Water Authority. (King)

A soil map was provided for planning the 1983 *Farmers Weekly* National Drainage Demonstration at Embleton, Northumberland. (Kilgour and Payton)

Soil maps and reports were provided for the following proposed opencast coal sites: Northumberland—Woodhead (148 ha), Durham—Red Barns (150 ha), Cumbria—Potatopot (290 ha), Lancashire—Ellerbeck North (56 ha), Staffordshire—Streets Lane (200 ha). (R. A. Jarvis, Carroll, Furness, King, Bendelow and Payton)

Judging was undertaken at the Humberside Young Farmers soil assessment competition. (King)

Soils at Westfield Farm, Nafferton, Humberside were surveyed and their suitability assessed for irrigated strawberry growing. (Furness)

A poster display illustrating soil criteria in upland land use was prepared for the British Society of Soil Science conference, Aberystwyth. (Carroll)

Staff

B. W. Avery retired in August after more than 34 years' service. His dedicated approach to soil classification and other research areas has been an inspiration within and outside The Survey. His retirement and the resignation of B. Clayden, to take an appointment with the New Zealand Soil Bureau, have removed in a single year much of our expertise in soil classification. J. M. Hollis has been transferred from Wolverhampton to Rothamsted to work in this field.

D. Hall resigned and emigrated to South Africa and the vacant post in the Soil Water Laboratory has been filled by Andrée D. Carter.

Judie Reed resigned from the Cartography Section in April.

A new sub-centre has been opened at Newcastle University in accommodation provided by the Soil Science Department. I. Kilgour has transferred from Penrith and Robert Payton appointed in preparation for surveys of the Northumberland lowlands.

The sub-centre at Swansea University College has closed and Paul Wright has transferred to the Cambridge Regional Centre.

Jenny O'Donnell, Elaine Avis, Susan Nicholson, Debra Writer, G. P. Bailey, I. J. Fullstone and D. I. Bamford were appointed. We welcome the continuing support of Susan Harrop (née McVittie) following her marriage. A sandwich student, Helen Page was recruited to assist in the compilation of NATCAT text files.

R. A. Jarvis visited the Republic of Ireland at the invitation of An Foras Taluntais to discuss soil surveys for arterial drainage schemes.

P. Bullock and R. R. Furness attended the ISSS Congress held in India, the former to chair sub-commission sessions on Soil Micromorphology and to examine soils and land use in the Indo-Gangetic plain. He also visited CNRS and CNRF, Nancy, to talk on 'Measurement of Soil Structure' and to examine soils in the Ardennes, Normandy and the Vosges with Dr C. Nys from CNRF (see below).

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A. J. Thomasson visited (i) Jersey as guest of the States, to appraise the needs of the Island for soil surveys and land classification; (ii) France (Montpellier, Dijon and Angers) for discussions on the techniques and methodology of soil surveys and their applications to land drainage and classification; (iii) Yugoslavia, to read a paper on soil workability at the conference of the International Soil Tillage Research Organization, and for consultations on land drainage and land potential with staff of the Institute of Agro-ecology, Zagreb.

Visiting workers

Dr G. Callot, INRA, Montpellier, France, has worked on the role of fungi in mineral weathering and formation of minerals; Dr J. A. McKeague, Head of Classification Section, LRRI, Ottawa, Canada, on soil micromorphology and measurement of soil structure; Dr C. Nys, CNRF, Nancy, France, on the measurement of physical properties of forest soils; and Mr J. Xu has continued his work on the application of remote sensing and computing techniques to soil survey; he returns to China after a 2 year secondment in January 1983.

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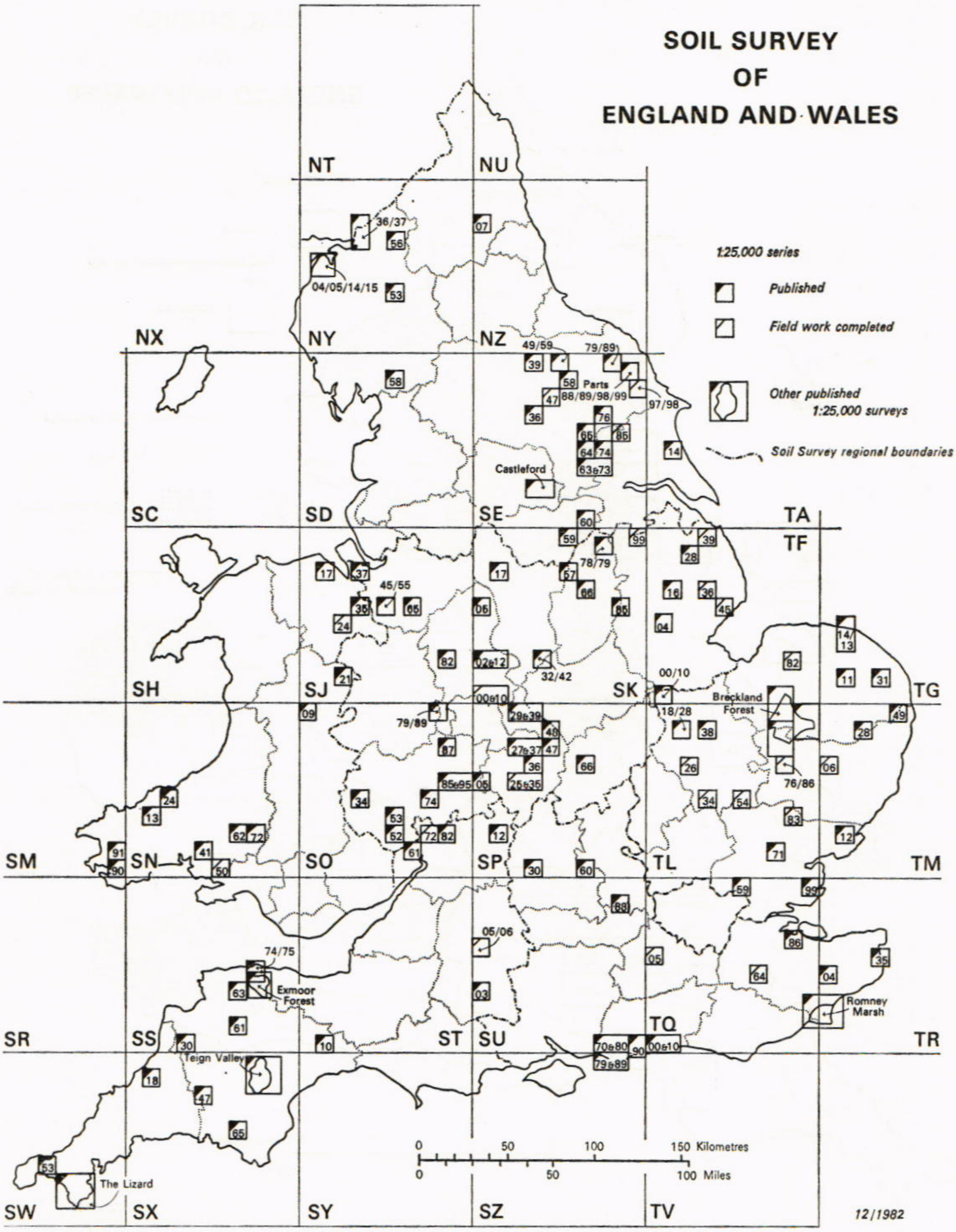

FIG. 5. Mapping completed and in progress. I. 1:25 000 scale.

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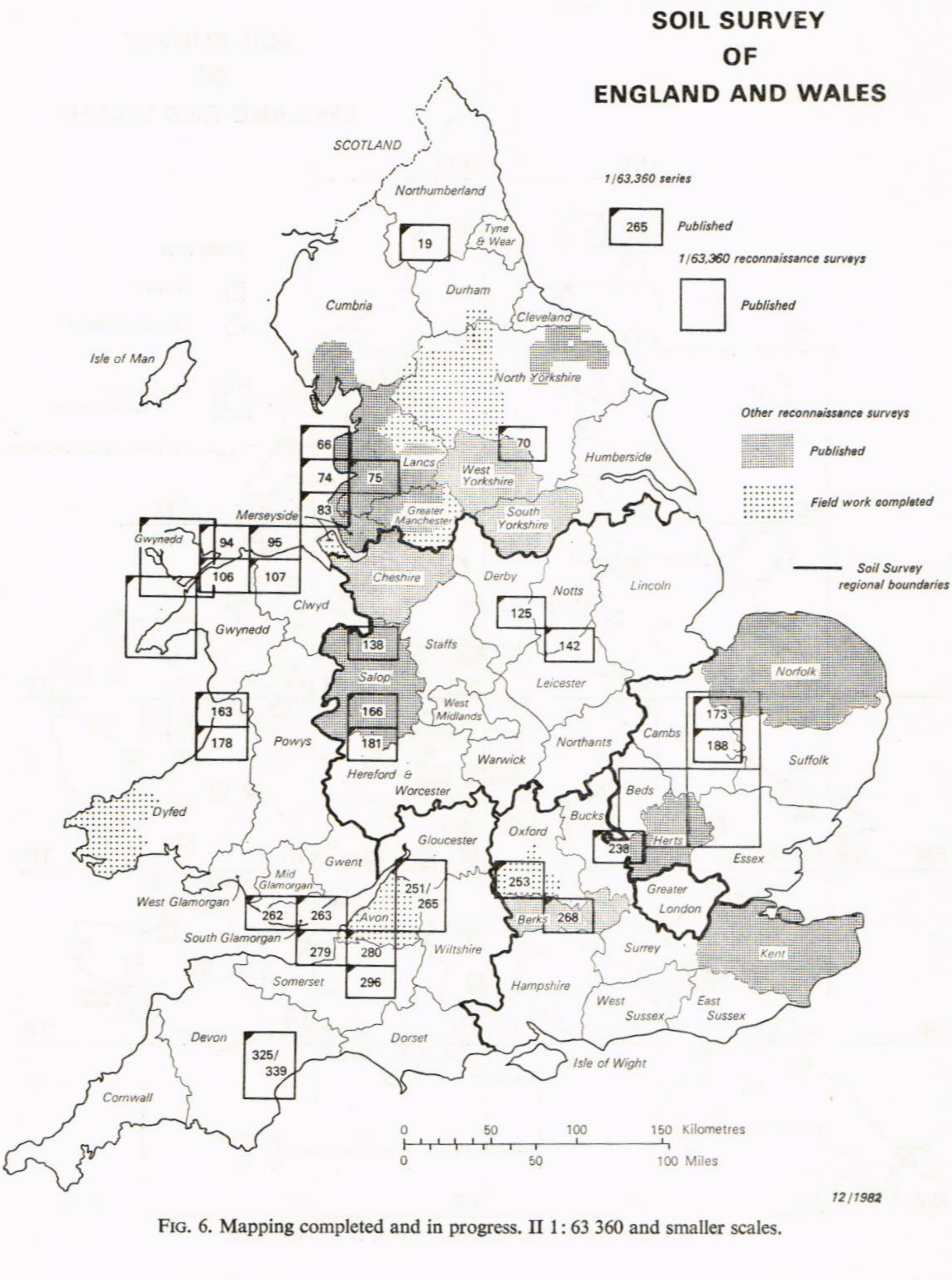

FIG. 6. Mapping completed and in progress. II 1: 63 360 and smaller scales.

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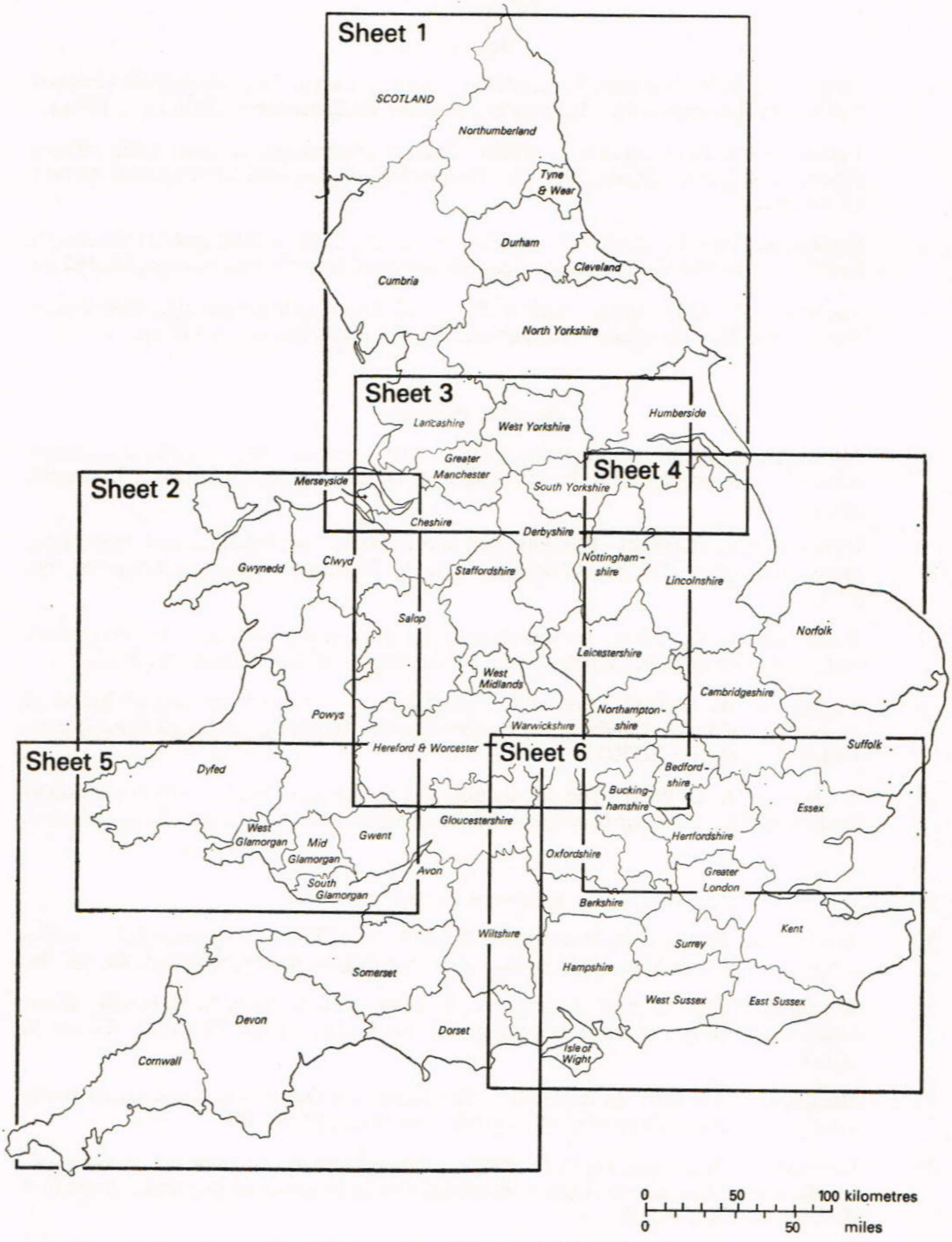

FIG. 7. Mapping completed at 1:250 000 scale.

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https://doi.org/10.23637/ERADOC-1-129

SOIL SURVEY OF ENGLAND AND WALES

Maps

1:250 000 National Soil Maps

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https://doi.org/10.23637/ERADOC-1-129