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AGRICULTURAL RESEARCH COUNCIL

Soil Survey of England & Wales.

The development of the Soil Survey
of England & Wales

by

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SUMMARY

The development of the Soil Survey of England and Wales over the past twenty years is briefly outlined, and, the need for it to provide information about the Soil for science, government, education and industry, is discussed.

The current programme of research on soil identification and classification, surveying techniques and cartographic methods supports the main aim of the Survey, to produce a national soil map.

To fully meet the scientific and other needs, a programme of surveying, map production and publication is planned, designed in stages. In the first stage selected ^{150 sq km} 23,000-acre areas in each county will be surveyed at a scale of 1:25,000, and reports and maps showing soil series will be published at short intervals. In the second stage, maps will be prepared for counties or groups of counties, by interpolation, using a scale of 1:250,000 and with soil associations as the dominant mapping units. Each sheet will be of standard size and accompanied by a Memoir. Later, combinations of sheets will be made to give regional maps, to be accompanied by Bulletins. In the final stage, the complete set of twenty-six sheets will constitute the first edition of a National Soil Map, and a Manual of the Soils of England & Wales prepared. ✓

A transitional stage lasting 2 - 3 years will be needed in which the present 1:63,000 mapping programme is concluded, and preparative work done for the new programme. It is impossible now accurately to forecast how long the present project will take, and progress will be reviewed at an early opportunity during the first stage, to make a reliable forecast.

1966
INTRODUCTION

At a meeting on April 21st, the Soil Survey Research Board agreed that a re-statement of the objectives of the Soil Survey of England and Wales was opportune, and an indication of how they are to be achieved.

After briefly reviewing the development of the Survey and its present organization, this paper notes that the aim must now be to meet the increasing needs of Science, Government, Education and Industry for information about the soil. Needs for these various purposes are noted, and their bearing on the distribution of effort and on dissemination of information is discussed.

The programme of mapping and publication to meet the wide range of needs is outlined. After a transitional period of 2 - 3 years, the policy will be reviewed to assess the progress.

DEVELOPMENT OF THE SURVEY

The Soil Survey of England and Wales was established in 1939 with Prof. G.W. Robinson as Director. Following re-organization in 1946, the Soil Survey Research Board was set up, and Dr. A. Muir succeeded Prof. Robinson as Head. The objectives were then summarized as the systematic collection of information on the most important classes of soil, their distinctive properties and their geographical distribution. It was also hoped to present a complete picture of the soil of the country to serve as a guide for agricultural planning⁽¹⁾. Concepts and methods have developed continuously since, as have the range of applications for the knowledge obtained, and in 1960 Muir noted the increasing value placed on soil maps for town and country planning, industrial development, forestry and horticulture.⁽²⁾

Soils are characterized by their appearance in profile⁽³⁾, profiles formed in a similar way but differing in texture being assigned to soil series. A classification for grouping soil series has been evolved⁽⁴⁾. Soil Associations or complexes are larger, ^{distinct areal} units containing several series, sometimes in repetitive patterns associated with land form, topography or drainage and sometimes in random arrangement. ^{unpredictable} Mapping in the field is most usually recorded on Ordnance Survey Sheets at a scale of 1:25,000 (2½ in./mile), and the results are published at

a scale of 1:63,000 (1 in./mile). Accompanying Memoirs describe both soils and their environment and, where appropriate, include sections on agriculture, forestry and other types of land use⁽⁵⁾.

More recently the scope of the work has been extended to include the mapping of soil associations on a county basis. Shropshire, Cambridgeshire and Hertfordshire⁽⁶⁾ have been surveyed; and maps at a scale of 1:250,000 ($\frac{1}{4}$ in./mile) of Lancashire, Glamorgan, Monmouthshire and Breconshire are being published. The first regional survey, that of the West Midland region, has been published⁽⁷⁾, accompanied by a map at a scale of 1:630,000 (1 in./10 miles).

Numerous special surveys have been made in areas of particular interest to agriculture, horticulture, forestry and other industries. Maps have been published, or are in preparation, at a scale of 1:25,000 ($2\frac{1}{2}$ in./mile) in three of the most important areas, viz. the Romney Marsh, the Sussex Coastal plain and the Middle Teign Valley. A Bulletin accompanies the last⁽⁸⁾.

Parallel to, and supporting, the work on mapping, a range of investigations have been made in both the field and the laboratory to establish more accurately the characteristics of particular soils. These are concerned with subjects as various as geomorphology, pedology, soil chemistry, physics and mineralogy and ecology. The papers published are given in Appendix 1.

THE NEEDS OF SCIENCE

The main scientific need that survey must meet is to characterize, group and record the soils of England and Wales. The work sub-divides into:-

- Soil identification studies
- Soil classification studies
- Studies of surveying techniques
- Studies of cartographic methods

Table I lists individual studies within these four groups that are now in hand or in contemplation, and the present priorities. In most cases, work is in progress, and in some the first stage has been completed and published.

Soil identification studies. These are concerned with the

TABLE I
Research Programme

Main Heading	Subsidiary Heading	Centre	Priority	Remarks
A. Soil Identification	A.1 Influence of chemical composition on soil morphology	R.E.S.	1	
	A.2 Improved methods of chemical soil identification	R.E.S.	2	
	A.3 Clay mineralogy of typical English soil series	R.E.S.	2	In collaboration with Pedology Dept., R.E.S.
	A.4 Occurrence of natural phosphate in soils	Wolverhampton	2	
	A.5 Behaviour of iron oxides in pleying	Derby	2	
	A.7 Determination of soil moisture characteristics	R.E.S.		Awaiting decision by the S.S.R.B.
	A.8 Methods of assessing the stone content of soil rapidly	R.E.S.	2	
	A.9 Assessment of soil moisture regimes in the field	Derby	1	Work also at other Centres. Collaboration with N.O.T., M.A.F.E. Land Drainage Division
	A.10 Frost as a factor in soil formation	Leeds	1	
	A.11 Soil fauna in soil structure development	Wye	1	
B. Soil Classification	B.1 Development of a National soil classification	R.E.S.	1	Revision of Soil Survey Handbook in progress.
	B.2 Soil characteristics as aids in Agr. Land Classification	R.E.S.	1	Collaboration with M.A.F.F., A.L.S.

TABLE I (Contd.)

Research Programme

Main Heading	Subsidiary Heading	Centres	Priority	Remarks
	B.3 Associations of soil and vegetation	Cardiff Newcastle	1 1	Collaboration with Forestry Comm.
	B.4 Studies of peat soils	Glasgow Aberystwyth	1 1	Collaboration with M.A.F.F., Land Drainage Division
	B.5 Studies of grassland cereal soils	Newcastle	1	Collaboration with M.A.F.F.
	B.6 Studies of induration in soils	Exeter Cardiff	1 1	
C. <u>Surveying Techniques</u>	C.1 Studies of soils and land forms by Air Photography	Leeds Reading	1 2	Collaboration with Leeds Univ.
	C.2 Studies of soils through crop patterns on Air Photographs	Cambridge	1	Collaboration with Cambridge Univ. and M.A.F.F., N.A.A.S.
	C.3 Recording of morphological data in the field	Wolverhampton	1	
	C.4 Development of data storage techniques	Aberystwyth	1	
D. <u>Cartographic Methods</u>	D.1 Methods of preparing block diagrams	R.E.S.	1	In collaboration with O.D.N., D.O.S.

characterization of soils by fundamental parameters, both in the field and laboratory. This work complements that of the Pedology Department in the Rothamsted Experimental Station, whose objective is the study, particularly in the laboratory, of the ways in which soils are formed. The Survey is mainly concerned with the soils as they are, and occur in the field. Because soils become what they are as a result of the ways they are formed, the work of the two groups is closely interwoven, and distinctions disappear at the project level. Some investigations are, indeed, joint efforts.

In the laboratory, the Survey needs continually to improve the chemical and physical methods by which soils are characterized. Chemical and mineralogical techniques are being examined and more effort is to be devoted in the future to studying soil-moisture characteristics, following recommendations from the A.R.C. Technical Committee on Soil Fertility.

In the field, further work is needed to relate soil type to moisture regime and to the incidence of weathering by frost, investigations which have shown promise in the Midlands and the North. In the Welsh uplands soil-flora associations call for study, and there and in Lancashire studies of peat soils are yielding useful information and need completing.

Soil classification. Soil classification, on which all soil survey is based, involves the recognition both of those soils that can usefully be grouped together and those whose properties require separation into new groups. It is accomplished partly by visually assessing soil morphology, usually in the field, and partly by the use of the experimental techniques evolved for soil identification. It is thus both a science and an art, and aesthetic appreciation is often the means whereby physical and chemical differences first become apparent.

The enhancement of visual appreciation is probably a matter of recruiting suitable people, and subsequently of training. New entrants need to work beside experienced staff, and the biennial Field Meetings are valuable. However, there is a continuing need for the recording in print of experience, both of morphology and experimental evidence. An up-to-date edition of the Soil Survey Field Handbook, now under revision, is urgently needed, and it is hoped to produce this in the near future. It is planned to include a soil classification covering both England and Scotland. There is, in addition, a constant need for review of such a

classification to include new knowledge in soil science.

Surveying and mapping techniques Traditionally, the soil surveyor works by inspecting pits or augering holes, supplementing the information gained from this by inspection of solid and drift geological maps and topographical information. The advent of aerial photography has provided a valuable tool for inspecting large areas of the ground quickly, and the technique can also provide information about the surface layers of the soil.

The Survey has been active in examining two possible techniques whereby aerial photographs can be used in its work. The first is based on the assumption that particular soils are often associated with certain recurring features in the landscape, and is applicable mainly in areas of marked relief in England and Wales. The second is based on the appearance in photographs of standing crops of certain recurring patterns, reflecting the influence of the soil on plant physiology. Natural vegetation may also, under appropriate conditions, show patterns determined by the soil.

In the last two decades, techniques of aerial photography have considerably improved, and results can now be obtained that are considerably better than those from existing photographs, many of which are 15 - 20 years old. The two techniques, referred to above need further study with modern photography, and special investigations are to be carried out at two designated centres for this purpose.

Data recording and storage In recent years interest has developed in techniques of rapidly recording, analyzing and storing data relating to soils. In the first instance the application has been military, and the scope envisaged is world-wide.

Increasing information is being acquired by the Survey about profile morphology and laboratory testing, and preliminary experiments have been made at one centre (Aberystwyth) to develop a simple storage technique for quick reference. There is a need for further study to determine in detail what part such techniques can usefully play in the work of the Survey. The possibility of using portable tape recorders to collect field observations needs examining.

Cartographic methods New methods of visually presenting the results of the work of the Survey need to be examined as they emerge. A method for producing three-dimensional block diagrams by a combined photographic and scale-model technique has been evolved by the Cartographic

Department in the Directorate of Overseas Surveys, and this is now being studied by the Survey. To enable the cartographic work to take more rapid advantage of new developments, arrangements are being made for the Survey to be associated with the Ordnance Survey Advisory Committee on Survey and Mapping.

THE NEEDS OF GOVERNMENT

The soil is the most extensive and enduring of the nation's material resources, and as such is the concern of many departments of central and local government. The following are those most directly involved:

The Ministry of Housing and Local Government

The Ministry of Agriculture, Fisheries and Food

The Ministry of Technology

The Ministry of Public Buildings and Works

The Ministry of Transport

The Ministry of Power

In addition the Ministry of Overseas Development provides assistance to many overseas countries in studies of land use in which soil survey plays an important part.

The Ministry of Housing and Local Government. The M.H.L.G. is responsible for the location and planning of New Towns, and the nature of the soil in an area under consideration has an important bearing on both these aspects. Thus the Soil Survey has provided information, including maps, for planning New Towns in Lancashire, the West Riding, Wiltshire, Cheshire, Shropshire, Devonshire and Montgomeryshire. The work has developed most fruitfully in Lancashire where decisions involving the future housing of over 300,000 people have been influenced, and the sterilization by building prevented of valuable deposits of glass-making sand.

The map scales asked for by County Planning Officers have ranged from 1:250,000 in the West Riding to 1:25,000 in Shropshire. The Planning Services Department of the Ministry in London has also stated that information at these two scales will be of value to them.

A valuable feature of collaboration with the Ministry of Housing and Local Government is the use being made of the Ministry's Library of

Aerial Photographs in London.

Requests for assistance in planning currently reach the Soil Survey from the Ministry in several ways. Primarily they come through County Planning Officers, but requests are also received through Regional Offices of the Agricultural Land Service and from independent firms of planning consultants. It is felt that there is scope for some more efficient administrative arrangements involving the Ministry's London Office and Soil Survey Headquarters.

The Ministry of Agriculture, Fisheries and Food. The Agricultural Land Service is responsible for presenting evidence about the agricultural value of land during enquiries held into future development by the Ministry of Housing and Local Government. For this purpose a classification of land is needed, in which the nature of the soil plays an important part⁽⁹⁾.

The Agricultural Land Service has set up a Study Group to devise a system of classification, on which the Survey has been represented, and this has issued its first progress report⁽¹⁰⁾. It recommends the preparation of a national map of agricultural land, classified into five grades, at a scale of 1:63,000 (1 in./mile). Information will be needed from the Survey and it has been agreed that Surveyors at provincial centres will act as consultants.

The Agricultural Land Service is concerned with the provision of grants for Farm Buildings, and a knowledge of the quality of the foundation soil is often needed to enable a satisfactory structure to be designed and approved. The Survey is in a position to make general recommendations regarding foundation soils, and to indicate where and how more detailed information can be obtained, if needed. Advice is also needed by the A.L.S. from time to time on the soil aspects of reclamation problems e.g. following open-cast mineral workings, and in peat and fen country.

The Land Drainage, Water Supply and Machinery Division of the Ministry of Agriculture is concerned with the provision of grants for Drainage Schemes, and a Land Drainage Experimental Unit has been established to provide basic information. Because drainage is a major factor in the system of classification used in the Soil Survey, soil maps are of considerable interest to the Unit, which already employs the concepts evolved, and

they are of potential value in assessing grants. Since 1963, the Soil Survey has studied quantitatively soil-water regimes at four centres, to associate soil series and drainage classes more accurately, and this work needs to be closely associated with that of the Experimental Unit so that the possibilities of both can be fully exploited. Informal liaison already exists, and this is now being extended to the work of the Road Research Laboratory's Climate and Environment Section, which has a parallel interest in the moisture regimes of soils in road foundations (see below).

The Ministry of Technology (Building Research Station). The Soil Survey concerns itself with the top 3 - 5 feet of soil, which is the layer carrying a significant proportion of the stresses imposed by the foundations of single- and double-story buildings, which cover the major part of the area of the country given over to urban development. Soil maps are therefore of potential interest to Municipal Architects and local housing authorities. The work of the Survey is not very well known by these authorities, and as a first step the Building Research Station has agreed to include details of it in the next edition of their Digest No. 64, listing sources of information on soils and foundations. The need here is for the pedological terminology used by the Survey to be interpreted in terms acceptable to the Construction Industry, and further contact with the B.R.S. is required to effect this.

The Ministry of Public Buildings and Works. The Ministry of Public Buildings and Works is responsible for all direct Central (as distinct from local) Government expenditure on buildings and civil engineering, and in particular on that for the Armed Services. A proportion of the projects involve shallow foundations, such as airfield runways, and roads and buildings in service establishments, and three laboratories are maintained to test soils on a country-wide basis. A considerable store of information has been accumulated in two decades of work by these establishments and soil maps provide a rational basis on which it may be classified and retrieved for the benefit of future projects. A collaborative investigation is needed to determine how maps and data can usefully be collated, and a first approach is shortly to be made to the Ministry's central laboratory.

The Ministry of Transport. The part played by soil both as a foundation for roads and as a material of construction is described in a separate paper to the Board. The strength of soil foundations is determined by their moisture regimes, and these are being studied by the Climate and Environment Section in the Ministry's Road Research Laboratory. The relevance of the Survey's maps classifying soils on a drainage basis has been noted, and there has already been collaboration in a field experiment in Lancashire, while a further stage is planned.

The Ministry is now considering a method of selecting trunk-road routes by computer evaluation of factors such as topography, traffic and construction economics, and soil conditions. This approach will involve consideration of the landscape as a whole, and could well be extended to include consideration of the value of land for other purposes such as agriculture. The Ministry are keen to maintain contact with the Soil Survey as this investigation develops both to enable information from reconnaissance surveys to be made available and to develop methods of landscape classification.

The Ministry of Power The Ministry of Power has general responsibility for the electricity and gas supply industries, and, since 1962, for the construction and operation of pipelines. The influence of the nature of the soil on the construction and maintenance of pipelines and other underground services is given in a separate paper to the Board.

The development of most immediate interest is the construction of a trunk pipeline system to carry natural gas from the North Sea Coast inland to centres of population. It has been provisionally estimated by the Gas Council that some 1,300 miles of pipeline costing about £100 million will be needed. The Survey has made contact with the Council who are now familiar with the type of information that it can provide. Some work remains to be done to relate soil type with pipeline location, construction and maintenance, and there is a need for the Survey to develop closer contacts with the individual research organizations concerned.

Expenditure. To give a general idea of the magnitude of the public expenditure involved in some of the governmental activities referred

to above, the following figures for recent years in England and Wales may be quoted:

	£ million
Ministry of Housing and Local Government	
Ministry housing vote (1966) ⁽¹¹⁾	87
Local Government housing (1963) ⁽¹²⁾	356
Ministry of Agriculture, Fisheries and Food	
Grants, subsidies, price guarantees and agricultural services (1966) ⁽¹¹⁾	265
Ministry of Transport	
Roads vote (1963) ⁽¹²⁾	171
Ministry of Public Buildings and Works	
Civil, Army, R.A.F. and Min. Aviation votes (1966) ⁽¹¹⁾	176

The figures for 1966 are estimated, and those for 1963 real, expenditures.

Thus, the public expenditure on activities which, in one way or another, require a knowledge of the soil exceeds £1,000 million annually.

The Ministry of Overseas Development. As part of the government's programme of aid to developing countries, the Ministry of Overseas Development initiates surveys of resources through the Land Resources Division of the Directorate of Overseas Surveys. In the present phase, this includes a significant element of soil-survey work. Detailed surveys are often asked for, and the proportion of reconnaissance work is expected to rise.

Until recently, the Survey collaborated in maintaining in the United Kingdom a Pool of Overseas Soil Scientists, who could be sent abroad. This arrangement is now being wound up and staff hitherto working overseas are being absorbed into the complements of the Survey and the Division⁽¹³⁾. Occasions may still arise, however, when it will be desirable for Survey staff to work overseas.

It will be an advantage for the Survey to give junior members of the staff opportunity for a short period of overseas service early in their career, to develop initiative and responsibility. However,

the future need of the Division is likely to be for more senior staff secondment, because many overseas countries are recruiting their junior staff locally. The Survey will satisfy what requests it can for secondment, although this will inevitably slow the progress of its main work.

All future requests for work in developing countries, emanating either outside or from Survey staff themselves, will be channelled through the Land Resources Division, one of whose officers is permanently located at the Rothamsted Experimental Station. At this stage individual requests will be considered as they arise, possibly on the basis of exchange of staff, rather than by developing formal links.

As a service to the Land Resources Division, the Survey also undertakes the analysis of samples of soil sent in for identification from surveys overseas. Some 1,850 samples have so far been examined, and the laboratory staff has had to be strengthened by an Experimental Officer recruited by the Division. As this work cannot be expanded at the Rothamsted Experimental Station, the Division plans to develop independent facilities elsewhere, and this part of the Survey's work may well end during 1967.

THE NEEDS OF EDUCATION

Education has been defined as the means whereby individual people may experience to the full the possibilities of their present existence, and history can show that acquiring knowledge of the soil can be part of a good general education. Such experience can be acquired in schools, colleges and Universities, and the Soil Survey has developed close and fruitful relationships with all three. Analysis has shown that in 1965 over 60 per cent of the Survey's map sales were to educational organizations.

Schools. Soil Study is now in the sixth form curriculum for geography in schools all over the country, and teaching is in a national, regional and county context. Thus the Hertfordshire County Education Committee have bought 500 copies of the 1:250,000 soil map of the county. The need is to prepare large scale maps and encourage better liaison with county education authorities to make the existence of

maps known.

An indication of the value set upon such information by local authorities is seen in the reception given to Miss Alice Coleman's second Land Use Survey, now being recorded for many counties on 1:25,000 map sheets⁽¹⁴⁾.

Colleges. In 1964-5 there were 5 Agricultural Colleges and 40 Farm Institutes in England and Wales. The size of the student body is not known, but the Lancashire County Institute at Hutton and Winmarleigh has 161 resident and 600 day students. Approximately two-thirds take courses in Agriculture, Horticulture and Dairying involving studies of soils. A textbook on County Agriculture to be issued by the Hertfordshire County Institute of Agriculture will contain the 1:250,000 county map prepared by the Survey⁽⁶⁾.

Universities. Soil science is taught either as a main or component theme in at least nine Departments of Universities in England and Wales where in 1963/4 some 2,000 students were taking degree courses in Agriculture⁽¹²⁾. Soil studies are also being incorporated into the curricula for Departments of Geography to an increasing extent. The soil mechanics aspect of soil science is being taken up into the courses offered in Civil Engineering, and in Departments of Highway and Transportation, in ten Universities. Small scale maps of selected local areas used for teaching have been asked for, and the value of the present 1:63,000 maps for comparison with the corresponding geological sheets is noted. Many Universities have county or regional affiliations, and Soil Science and Geography Departments are also concerned with the national distribution of soils for which a 1:250,000 scale or larger is appropriate.

THE NEEDS OF INDUSTRY

Many industries have a direct or indirect interest in the soil. The most important are:

- Agriculture
- Forestry
- Extractive Minerals
- Construction
- Transport

The Agricultural Industry. The agricultural industry must remain for a long time to come the user of the largest area of soil, although by present methods of assessing the economics of land use, other industries may yield more per acre in money terms. The main channel through which information reaches the industry is the National Agricultural Advisory Service, whose soil scientists have described the circumstances in which soil survey data can be helpful⁽¹⁵⁾. These include:

- (1) The estimation of the cropping potential of land.
- (2) The establishment of soil conditions favourable to crop growth.
- (3) The selection of the soil most suitable for a crop.
- (4) The determination of the tolerance shown by crops to different soils.
- (5) The determination of the need for, and type of, drainage and irrigation.
- (6) The determination of physical defects in soils, and how they may be corrected.

It has been suggested⁽¹⁶⁾ that the usefulness of Soil Survey maps and publications could be increased by including more information on the following aspects:

- (1) The influence of husbandry and management of a virgin profile.
- (2) Quantitative variations in depth and thickness of horizons that influence the moisture regime and root development.
- (3) The nature and form of the parent material supporting the soil, because this also influences moisture and root distribution.
- (4) The average number of growing days, and the distribution and quality of root systems.
- (5) The structure of soil and its stability and porosity, the soil moisture regime and its annual variation, local meteorological and hydrological information, and the summer moisture deficit.

- (6) The chemical characteristics of the soil, including oxygen tension and trace element status.

To the extent possible with existing staff, observations under headings (1) to (4) are being made, and the Working Party on Soil Classification and Fertility is to recommend to the Board that additional staff be provided to include observations under heading (5).

Stewart has pointed out that the concept of soil fertility should be made more precise by basing crop studies on soil maps⁽¹⁷⁾, which should record permanent rather than transient properties, and be followed by field experiments to obtain quantitative information on crop performance. To this end the Survey studies the sites of field trials, for example those done by the N.A.A.S. and by the Broom's Barn Experimental Station.

Ideally, the N.A.A.S. needs to have soil maps for the whole country on a scale at which the fields on individual farms or estates can be identified, i.e. 1:10,000 or 1:25,000. This ideal is recognized as impossible to achieve in any reasonable time with an organization of the present size. Instead it has been agreed that a useful stage in development would be to survey between four and eight key areas in each county. Descriptions, published quickly, of the major soil series and associations in each key area would provide Advisory Officers with the necessary minimum of guidance in the soil aspect of their work.

A factor making for close co-operation between the Soil Survey and the N.A.A.S. is the location of the provincial Survey Offices in buildings occupied by the latter, usually in the same corridor. Possibly because of this close association, and partly also because of the considerable local knowledge gained by senior officers in the Survey, some of them become involved in advisory work relating to problems of soil use. Many formal requests for advice are also received both at the local offices and at Headquarters.

It is recognized that it is a proper return on public expenditure for the experience of a Survey Officer to be used by the Agricultural, or any other, Industry. However, the chief function of the organization is to survey and map soil, and in future advisory work will be undertaken directly only when one or more of the following

criteria are satisfied:-

- (1) It can be expected to yield information of value in a research project.
- (2) It will provide data of value in the local mapping programme.
- (3) It is in return for help received in another direction with the work of the Survey.
- (4) It cannot be undertaken by an appropriate advisory body, such as the N.A.A.S.

The Forestry Industry. Requests for assistance come to the Survey through the Forestry Commission. Soil information is useful in preparing working plans and planting programmes, and has been supplied for forests in the Border Country, Wales and the West Country. Help has also been given in the classification of soil on experimental plots, and the Survey has collaborated in an investigation of tree stability, which is greatly influenced by soil conditions.

The Forestry Commission has begun independent soil survey work, and the need now is for continued collaboration. This will be aimed at introducing concepts from the national survey into the Commission's work, and where possible integrating the Commission's survey work into the local mapping programmes.

Extractive minerals. Soil Survey information can lead to the discovery of exploitable materials other than soil. Examples are glass sand and horticultural peat in Lancashire, and gravel in West Sussex. A report on the last has been prepared for the Ministry of Housing and Local Government. The Survey is also asked for advice in connection with the reclamation of land from which minerals such as coal and iron ore have been extracted, and collaboration continues with the Opencast Coal Restoration Committee.

Assistance is also provided to the Hydraulics Research Station and the Water Research Association of the Ministry of Technology, and to local River Boards, in assessing the drainage properties of the soil types occurring in catchment areas.

This type of work touches closely on the economic geology done by the Institute of Geological Sciences, and close collaboration

is needed to avoid duplication of effort. It is probably not desirable to draw a rigid boundary between the activities of the two bodies, but it is suggested that the Survey should concern itself chiefly with minerals arising from recent pedological effects, and undertake surveys for specific minerals in surface strata only when the G.S.I. cannot do so.

Construction and Transport. For the design of dwelling houses architects need to know in general terms the types of soil they are dealing with on a field or estate basis, and their requirements in this respect resemble those of Advisory Officers in Agriculture. Advice on the location of well-drained soils with good bearing capacity is valued, as are indications of troublesome ones like peat and clays liable to swell and shrink. Maps showing soil series and at a scale of 1:25,000 are likely to be useful, particularly in areas adjacent to existing towns. Much of the mapping already issued or in the press is in this category, and the building industry needs to know of its existence.

Complete coverage of the country at a scale of 1:25,000 is unlikely to be needed by the construction industry, and its requirements will be met by appropriate location of the key areas of mapping referred to earlier. The character of the region will have to be taken into account. Thus in the predominantly agricultural counties of East Anglia, key areas will have to be located by reference to geomorphology and agricultural importance; in the more populous South-east the likelihood of future urban development will have to be given greater weight.

Soil surveys are a necessary adjunct to the determination of the route and the design of a new highway⁽¹⁸⁾, and the Road Research Laboratory has drawn attention to the usefulness of the Survey's maps in this connection⁽¹⁹⁾. Some 1,500 miles of new roads are built annually, mostly unclassified⁽¹²⁾. Public inter-urban roads are usually designed by the County Surveyors, who sometimes consult the Soil Survey. As an example the extent of a peat bog on the line of the proposed Manchester - Preston motorway was indicated to the County Surveyor of Lancashire.

Of the forty-five County Authorities in England, thirty-three maintain laboratories to make soil surveys for roads, as do three in Wales. The remaining authorities can consult the dozen or so private firms who carry out civil engineering soil surveys under contract. By providing soil maps the Soil Survey can make the work of these public and private bodies more effective. Classifying into soil series and associations not only lessens the number of borings needed, but also the amount of subsequent testing in the laboratory.

A proportion of the new roads built each year are in connection with housing, and the needs for soil maps will take the form referred to earlier for the Construction Industry. The balance will be inter-urban roads, for which maps at a scale of 1:25,000 and 1:10,000 of rural areas will be helpful in the design of individual roads. Again, the ratio of urban to inter-urban roads will vary in different countries and regions, and their anticipated future needs for roads will influence the location of key areas in mapping.

The construction of inter-urban and rural district roads is a county responsibility, so larger scale County Soil Maps will also be of value.

Discovery of natural gas under the North Sea and technical developments in the use of pipe-lines, the cheapest form of transport for many materials, are likely to increase such installations greatly. A separate paper (Board Paper No. BP/3) reviews how soils affect transmission and pipe-lines, and notes that the Survey is well placed to advise in questions relating to location, design, construction and maintenance. The need is for the information the Survey can provide to be more widely known, and to find out what extra observations need making to increase the help the Survey can give. The Survey is to increase its contacts with the relevant industries to find out what can usefully be done.

Summary of industrial needs. The industries with which the Survey is concerned are chiefly, although not exclusively, interested in small scale maps. A scale of 1:25,000 probably represents the lower limit to which the Survey can go in a general mapping programme with its present staff. Maps at this scale will provide general guidance in a wide range of industrial circumstances, leaving to

specialists within each industry the task of mapping individual fields, sites or lines in the greater detail they need, and with the appropriate emphasis in applied science.

It is not practicable, and possibly not even desirable, that the Survey should attempt to provide industries with information about soil in a directly useable form. It will aim, however, to provide a framework of fundamental parameters from which directly useable data can be inferred, to improve the efficiency of industrial survey operations, to facilitate assessments of the needs of different industries, and to encourage technical collaboration between those who use soil for different purposes. Where a new industry emerges as a potential user of the soil it is however, a proper objective to provide it with soil information in a directly useable form until such time as the industry can arrange to do this work itself.

Soil map is key to data store.

The needs of industry point also to the desirability of county and regional mapping, and will appropriately be taken into account in assigning priorities to sample or key areas to be selected for a general programme. Agricultural interest will predominate in selections made, for example in East Anglia, whereas the interest of the Construction Industry will be mostly in the South-East.

MAPPING AND PUBLICATION PROGRAMME

To meet the needs of different users of soil, a mapping and publication programme is to be instituted along the following lines:

The transition stage. Some eleven sheets of 3rd edition 1:63,000 scale soil mapping are now being prepared with field surveying mainly at a scale of 1:25,000. About half of these will by the end of the year have been taken to the point where more than half the field work will have been done. These sheets will be completed and published at a scale of 1:63,000 albeit without accompanying memoirs. The field observations for the remaining sheets will be recorded and filed for future reference.

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Stage I: Advisory scale mapping. Within each county, between four and six areas will be identified that have particular geomorphological significance or, where appropriate, are of particular interest to the agricultural industry; the second type will be chosen

on the recommendation of the N.A.A.S. These areas will then be surveyed in the field at a scale of 1:25,000 using soil series as the dominant mapping unit. Areas of 36 sq. miles corresponding to the Ordnance Survey 10 Km. x 10 Km. Outline Edition 1:25,000 maps will be used, and the resulting map will be published at that scale in black, grey and white, and soil areas will be given symbols so that copies can be hand coloured. Between 100 and 500 copies will be prepared at an estimated cost of £65, and each will be accompanied by a Report giving details of soil characteristics and morphology for the series concerned. The aim will be for each surveyor in the field to produce one such map, with report, within 12 - 18 months, and the material will be primarily intended for district agricultural advisory work. In this connection it is believed that the Geological Sciences Institute is also considering publishing its field work on 1:25,000 sheets.

Stage II; County mapping. On completion of the required number of 1:25,000 units, maps will be prepared for each county or for a group of counties, at a scale of 1:250,000 using soil associations as the dominant mapping unit. Interpolation will here be needed between the separate blocks mapped in Stage I, and air photography, and solid and drift geological maps will be used as much as possible. About 15 per cent of the area will have been covered by ground survey.

The material will be published at a scale of 1:250,000 on coloured sheets using the coverage indicated on Fig. 1. This system is designed for a standard sheet size which will accommodate the largest single county, or combinations of two or three of the smaller ones.

The standard sheet size will be 23 inches x 24 inches, an area which will also contain the legend and ancillary information. For comparison, the standard sheet size for the Ordnance Survey 1:250,000 topographic 5th series mapping is 31 inches x 24.5 inches. These latter dimensions, which will sometimes cover 12 to 15 counties or parts of counties on a single sheet, are unsuitable for immediate soil mapping because of the larger areas involved.

England and Wales will be covered by 26 of the proposed standard sheets (Fig. 1). A group of two or three counties will usually be published on one sheet, although the larger counties -

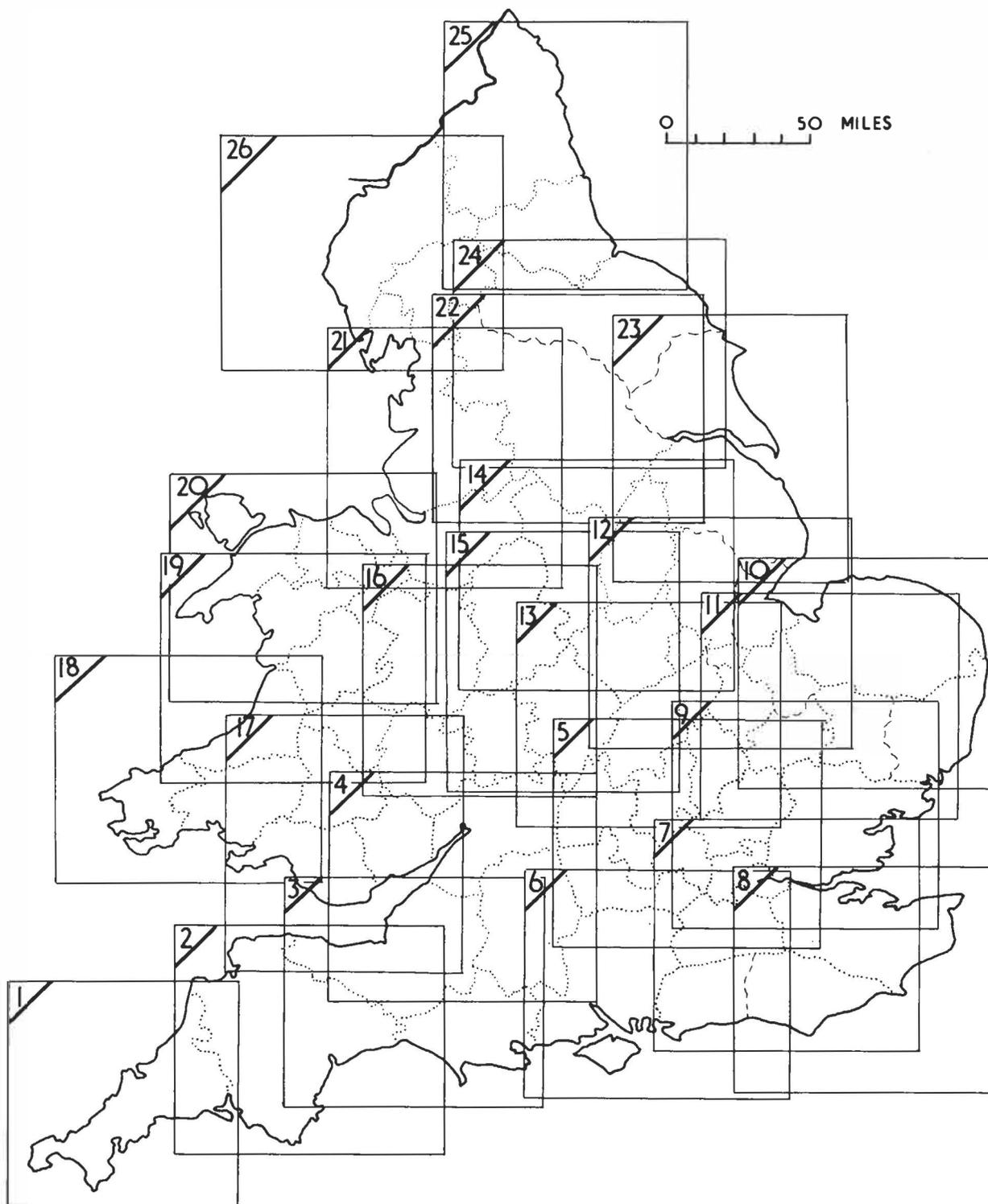


Fig. 1. Coverage of England and Wales by standard 1:250,000 soil maps.

Lancashire, Devon, Cornwall and the Ridings of Yorkshire will be published on one sheet. The individual counties or county groups are shown graphically in Fig. 2 and listed in Table II. Groups have been made for geographic and cartographic reasons, and with reference to present N.A.A.S. provincial boundaries. In Fig. 2, the groups are shown in relation to the new National Economic Planning Regions (see below). In Table 1 the proposed sheets are grouped by reference to present N.A.A.S. provinces, each province being covered by between 2 and 4 sheets. Each sheet will cover about one-and-a-half million acres.

7
meaning
The Ordnance Survey are keen to produce sheets of this type, which will be prepared by a technique similar to that used for the present 1:63,000 soil maps, using identical colours. An approximate estimate is that the printing costs will be comparable to that for the 1:63,000 sheets, i.e. £1,000 for 1,500 copies.

An idea of existing information for the 1:250,000 sheets is given on Fig. 3 which shows the extent of reconnaissance mapping already carried out by the Survey.

Each of the standard sheets will be accompanied by a Memoir, similar in structure to the present series, containing general notes on geology, geomorphology, pedology and land use including agriculture. The material will be primarily intended for county agricultural advisory work, education and land use planning.

Stage III; Regional mapping. Sets of single or multiple county maps prepared in Stage II will then be combined to either a regional map or set of maps, to accompany a Bulletin for the region. This would provide the basic data for soils and landscape given in the Memoirs, and also include a wider range of land-use information covering, for example the construction industry and transport.

The grouping will be that of the new National Economic Planning Regions (Fig. 2), which have been developed by the Department of Economic Affairs, for national planning. These are now being brought into use by a range of government departments, and are to be the future basis for the collection of statistics and planning.

TABLE II

Sheet numbers, acreage, County and N.A.A.S. Provincial groupings
of standard 1:250,000 soil maps

Sheet number	County grouping	Mapping acreage	N.A.A.S. Province
1.	Cornwall	900,000	S.W. Province
2.	Devon	1,800,000	
3.	Dorset & Somerset	1,600,000	
4.	Gloucester & Wilts	1,700,000	
5.	Oxon, Bucks & Berks	1,500,000	S.E. Province
6.	Hants & Isle of Wight	1,100,000	
7.	Middlesex, Surrey & Sussex	1,550,000	
8.	Kent	1,000,000	
9.	Norfolk & Suffolk	2,200,000	E. Province
10.	Lincs (part of), Northants (part of), Hunts & Cambridge	850,000	
11.	Beds, Herts & Essex	1,700,000	
12.	Leicester, Northants (part of) & Rutland	1,200,000	E. Midlands
13.	Derby & Notts	1,100,000	
14.	Lincoln (part of)	1,400,000	
15.	Cheshire, Salop & Staffs	2,200,000	W. Midlands
16.	Hereford, Worcester & Warwick	1,600,000	
17.	Anglesey, Caerns, Denbigh & Flint	1,200,000	Wales
18.	Merioneth, Montgomery & Radnor	1,200,000	
19.	Cardigan, Pembroke & Carmarthen	1,400,000	
20.	Brecknock, Glamorgan & Monmouth	1,300,000	
21.	Lancs	1,200,000	Lancs & Yorks
22.	Yorks (West Riding)	1,300,000	
23.	Yorks (North Riding)	1,400,000	
24.	Yorks (East Riding)	800,000	
25.	Cumberland & Westmorland	1,500,000	N. Province
26.	Durham & Northumberland	1,900,000	

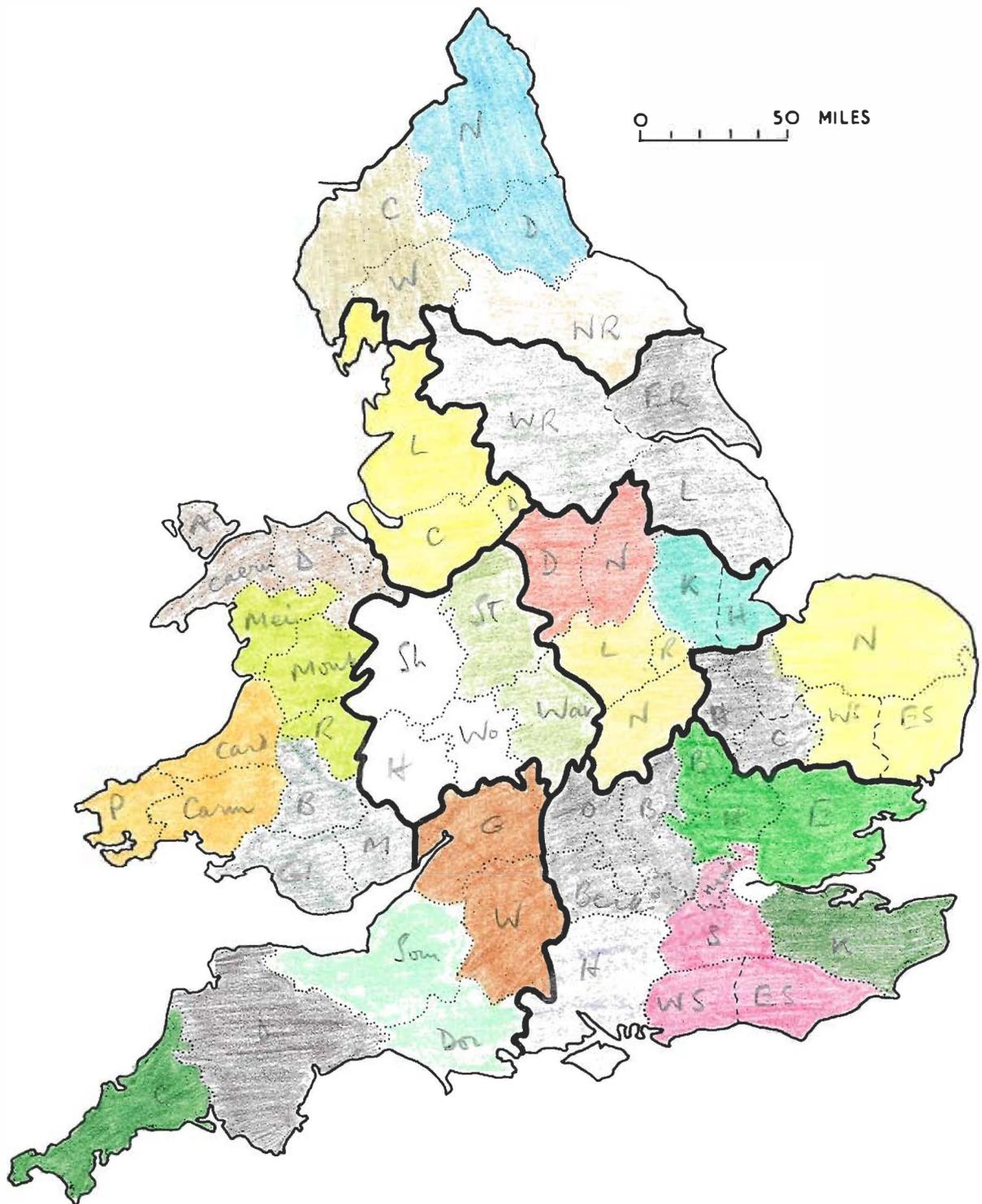


Fig. 2. Standard 1:250 000 soil maps for counties or groups of counties in relation to the National Economic Planning Regions.

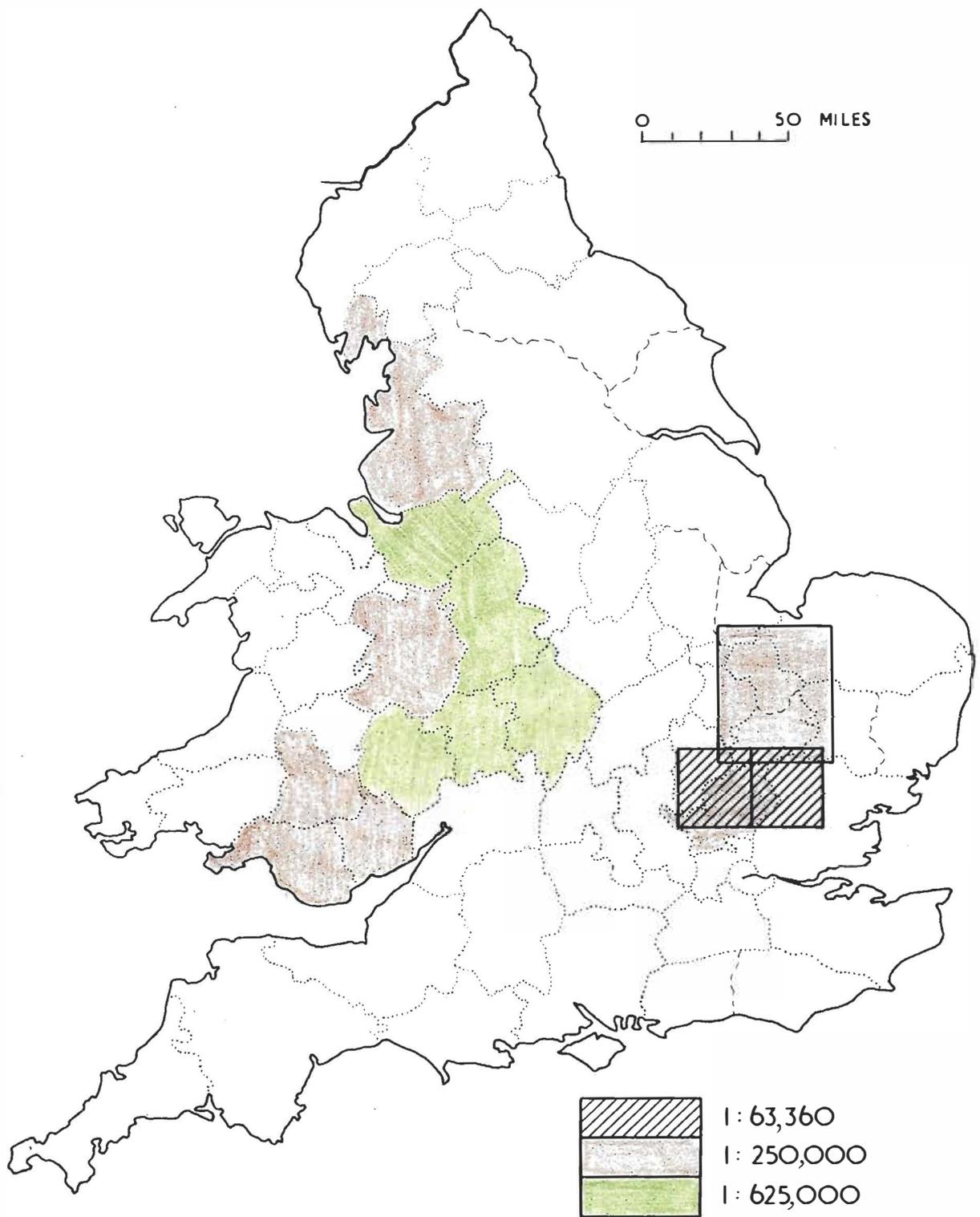


Fig.3. Extent of reconnaissance mapping in England and Wales in 1966.

This material will be primarily intended for regional and central government planning, for higher education, and for research.

Stage IV: the National Soil Map. The complete collection of twenty-six sheets will constitute the first edition of a National Soil Map. Consideration can be given later to the production of large sheets covering all England and Wales and suitable for display in classrooms and lecture theatres.

The complete set of standard sheets could usefully be accompanied by a Manual of the Soils of England and Wales, prepared by senior officers of the Survey, and embodying the material collected in the Regional Bulletins. Such a publication would fulfil a long-felt need for a teaching text book and work of reference.

ADMINISTRATIVE CONSIDERATIONS

Regional organization. The Survey operates at present through thirteen Centres; Aberystwyth, Bristol, Cambridge, Cardiff, Derby, Leeds, Newcastle, Norwich, Ormskirk, Reading, Starcross, Wolverhampton and Wye (Fig. 4). All the Centres work directly to the Headquarters at the Rothamsted Experimental Station.

Both technically and administratively the time has now arrived when some form of grouping is desirable. County and Regional mapping and publication, discussed earlier, will require a more intensive local correlation. To use the scientific staff of the Survey most effectively, more local administrative guidance is also needed. It is therefore proposed to designate offices as Provincial Centres, which will act as local headquarters for the regions indicated in Fig. 2. These, with the counties with which they will serve, will be:-

<u>Bristol</u>	Cornwall, Devon, Gloucestershire, Somerset and Wiltshire.
<u>Cambridge</u>	Cambridgeshire, Huntingdonshire, Norfolk, East and West Suffolk.
<u>Cardiff</u>	The Principality of Wales, Monmouthshire.
<u>Derby</u>	Derbyshire, Leicestershire, Lincolnshire (Kesteven and Holland), Northamptonshire, Nottinghamshire, and Rutland.

Leeds Cumberland, Durham, Lancashire, Lincolnshire (Lindsey),
Northumberland, Westmorland and Yorkshire.

Wolverhampton Herefordshire, Shropshire, Staffordshire, Warwickshire
and Worcestershire.

Harpden Bedfordshire, Berkshire, Buckinghamshire, Essex,
Hampshire, Hertfordshire, Kent, Oxfordshire, Surrey
and Sussex.

The senior officers at each Provincial Centre will be responsible for the scientific work of the staff working in their region, act as correlators in the work of mapping, and carry out administrative duties delegated to them.

Headquarters staff. The Head of the Survey is responsible to the Agricultural Research Council, through the Director of the Rothamsted Experimental Station, for both the scientific direction and for the general administration of the Survey. There are at present, however, no staff with specifically administrative duties in the Survey, and the burden of these is therefore carried by the Head to the detriment of the scientific side of the work.

There is an urgent need for a registry of correspondence. The headquarters office is currently handling 2,600 outgoing items annually, a figure which has risen 10 per cent annually over the last three years. The work is being done by a Shorthand Typist, Grade 1, who is able to devote no more than 20 per cent of her time to registry work. Enquiry at a major government research establishment, revealed that seven full-time staff are needed to handle 40,000 items annually. Clerical assistance is therefore needed, to develop and maintain a registry service, not only for the Headquarters office, but also for the Provincial and other Centres. The latter are handling more modest but increasing volumes of correspondence, and while in some cases satisfactory arrangements have been made, in others the lack of proper records is an impediment to effective work.

Financial control. By 1967 the expenditure on the Survey is expected to exceed £100,000 of which 75 per cent approximately goes to salaries, 15 per cent to publications and 10 per cent to travelling. General control is exercised by the Secretary of the



Fig. 4. Provincial centres of Soil Survey of England and Wales.

Rothamsted Experimental Station, but detailed supervision is a matter for the Survey. The necessity for this is evident from the fact that all travelling had to be suspended during one financial year owing to overspending. Here again, there is a need for clerical assistance in handling financial details relating to salaries and expenses, to promote closer control.

DISSEMINATION OF INFORMATION

The policy, pursued so vigorously by the previous Head of the Survey, Dr. D.A. Osmond, of publishing the work of the Survey as rapidly as possible is now bearing fruit. An increasing number of Memoirs and Bulletins are being prepared, more are expected and the preparation of Reports to accompany the 1:25,000 Advisory scale maps will add to this work. The preparation of publications is the responsibility of a Senior Scientific Officer and steps are being taken to recruit an Assistant Experimental Officer to assist him.

At most Centres officers of the Soil Survey are invited to give lectures and talks to audiences varying from undergraduates in Soil Science Departments to members of the general public. For lay audiences or farmers it is suggested that the policy should be to accept such invitations only when the talk cannot be given equally well by a Soil Scientist in the National Agricultural Advisory Service. For audiences at Universities or Technical Colleges it is suggested that the policy should, where practicable, be to initiate lectures on soil survey and local soils, in the hope that these would then be continued by the staff of the establishments concerned. Lectures to final year or post-graduate students in Universities, dealing with recent developments in Soil Survey would remain a continuing responsibility, as would papers to learned societies and Soils Discussion Groups.

Both at Headquarters and at the Centres the Survey welcomes many visitors from home and overseas who come to learn of its work. For their information a small pamphlet is to be prepared describing the aims and work, and how access to the results may be obtained. This pamphlet should also be useful to send to farmers in areas intended for survey, when access to their land is being sought.

For the specialist enquirer, a list of papers and articles published by the Survey has been completed (Board Paper No. BP/4), and it is proposed to issue this as a pamphlet.

CONCLUSIONS

See Summary.

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