AGRICULTURAL RESEARCH COUNCIL

Soil Survey of England & Wales

Air photo interpretation for soil survey in the Pennines

by

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Board Paper
No. BP/17
October, 1969.

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SUMMARY

The value of air photography in soil survey has been tested in two areas of the Pennines in the West Riding of Yorkshire. Most boundaries located by air photos were confirmed by subsequent field observations, and maps of soil associations at a scale of 1/25,000 were compiled more quickly than if they had been made by field work alone. The greatest advantage in the mapping of upland areas is thought to lie in the preparation of maps at a scale of 1/250,000 and it is proposed that an Assistant Experimental Officer be recruited to enable this to be done as a routine measure.

The 1970 programme of work of the Upland Air Photo Unit is described, including the commissioning of experimental photography. Collaboration with other organizations will continue.

INTRODUCTION

In October 1966, a paper outlining the future development of the Soil Survey of England and Wales was presented to the Soil Survey Research Board(1). A new mapping programme was described and the possibility of using aerial photography to speed the progress of soil surveying was noted. A further Board Paper in the following year proposed a research unit to study how aerial survey techniques could be used in upland areas(2), and an Upland Soils Photo-Interpretation Unit was established at Leeds in October 1968.

This paper suggests reasons why systematic photo-interpretation has been so rarely used by soil surveyors in England and Wales and the principles of the method are briefly explained. The progress of the Photo-Interpretation Unit during its first year's operation is described. Some preliminary results are presented and the paper concludes with a summary of future plans for the unit.

AIR PHOTOS AND THE MAPPING OF UPLAND SOILS

Aerial photographs have been used extensively by American and Russian pedologists for over thirty years and are today regarded as essential soil survey tools in most countries. Workers in Britain, however, have made comparatively little use of them. Their application, in England and Wales, has been mostly confined to aiding ground mapping and supplementing the base map in areas of featureless uplands or where extensive redevelopment has taken place, and there have been few attempts at systematic photo-interpretation.

The reasons for this are partly the inadequacy of the materials hitherto available and partly the previous mapping policy of the Survey. There is no uniform photographic cover of the United Kingdom and much of the available photography is often of poor quality, taken at many different times and sometimes at unsuitable scales for soil survey photo-interpretation. Surveyors have also found it difficult to learn the extent of photo-cover of their mapping areas as there is no central register of aerial photography. Furthermore, most photography is still taken with panchromatic (black and white) film and it is only recently that technological advances have permitted the pedologist to examine whether additional benefits can be obtained from infra-red and colour photography or airborne radar.

The previous policy of the Soil Survey of England and Wales has been to use a mapping scale of 1/10,560 (6 inches to 1 mile) and work has largely been in lowland arable areas of agricultural importance. Photo-interpretation of such terrain may sometimes add little to information collected during ground mapping at this scale, as an investigation in the Reading area has illustrated(3). Experience, however, has shown photo-interpretation to be useful in upland areas or in certain lowland areas, where crop and tone patterns are clearly visible on the photographs(4). The introduction of the new mapping programme has resulted in renewed interest in the possibilities of using aerial photographs of such areas as a basis for mapping and for rapidly extrapolating the results over wider areas.

Soil mapping is one of the more difficult branches of photo-interpretation as it greatly relies on inference. At best, only the soil's surface can appear on an air-photo and this, under British conditions, is covered by vegetation or crops for much of the year. The identification and classification of soils, however, is based on the characteristics and arrangement of their constituent horizons as seen in vertical profile. Changes in important properties such as the presence or absence of ironpan or a gleyed horizon or the nature of the soil's parent material can be inferred from the air photo when they are reflected by a change in surface features.

The photo-interpreter separates bodies of soil by the tone and texture (the arrangement and frequency of change of tone) of their photo-images and their shape and position in the landscape. A very valuable aspect of this method is that combinations of these properties often recur in patterns; information gained from detailed observations of sample sites can thus be extrapolated over much wider areas. Stereoscopic examination, with a knowledge of ground conditions, allows the pedologist to correlate these patterns of surface features with soils.

The closest correlation between vegetation and landscape patterns, seen on air photos, and soil distribution might be expected in upland Britain, where semi-natural vegetation and clearly defined breaks and inflexions of slope are often found. Work by Curtis in Exmoor(5), Crampton in Wales(6) and several members of the Scottish Soil Survey has confirmed this view.

PRESENT POSITION OF THE PROJECT

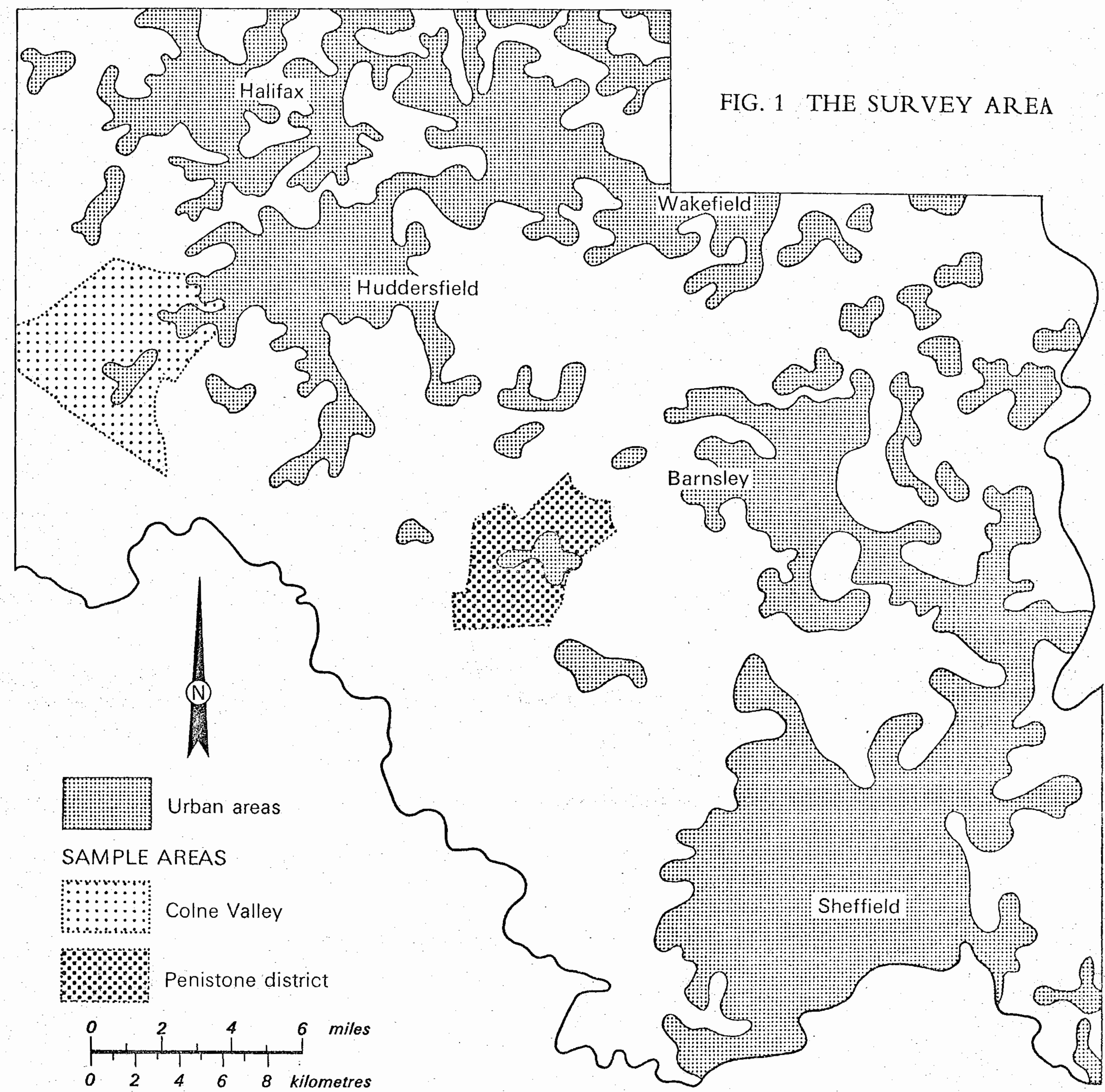
Working material

Panchromatic photography of the West Riding of Yorkshire, commissioned by the County Council, became available in 1968-9. This is of excellent quality, but suffers from having been taken in several sorties at different times of year. Also, the scale of 1/10,500 has been found to be rather too large, as only small areas can be examined at one time and the mass of fine detail on the prints is often confusing. A scale of 1/20,000 has therefore been specified for new photography.

The survey area (Fig. 1)

Part of the West Riding, consisting of Millstone Grit and Coal Measures strata, was chosen for detailed study after preliminary examination of the photography. Conditions for photo-interpretation are excellent as the shale and sandstone sequences, rarely complicated by glacial drift, give rise to clearly defined land forms. Semi-natural vegetation is found over much of the area.

FIG. 1 THE SURVEY AREA



In the west, the Pennines rise to over 1700 ft.; they are flat topped, peat covered moorlands, broken by deeply idented valleys and surrounded by stepped scarp faces. To the east, the general level of the ground declines and the Millstone Grit gives place to the Coal Measures, which form gentler rolling country with prominent scarps and long dip slopes extending in successive waves towards the north-east. There are several major eastward flowing rivers, the Don and the Dearne forming wide alluvial tracts. In the east, below the bold escarpment of the Magnesian Limestone, there is a narrow strip of featureless low lying land mostly formed from shale.

A notable feature is the high proportion of non-agricultural land, the area including Sheffield, Barnsley, Halifax, Huddersfield and many small towns. Old mines and quarry workings scar the landscape and part of the area has undergone recent opencast mining. The various classes of non-agricultural land can be quickly and accurately identified from the aerial photographs.

Procedure

After a brief field reconnaissance of the survey area, a stereoscopic examination of the air photos was made between November 1968 and April 1969. Land form boundaries and the tone patterns associated with different plant communities were marked on the photographs. Patterns resulting from differing parent materials, drainage conditions and land use were also recognized. The mapping units of this photo-analysis, chosen so that each contains only a limited range of parent materials and profile types, were plotted on 1/25,000 map sheets.

Two sample areas were then selected: the Penistone district, representing the Coal Measures 'scarp and dip-slope' terrain (Fig. 2), and the Colne Valley, representing the Millstone Grit uplands (Fig. 3). These areas together total about 100 sq. km. or 7 per cent of the non-urban land

FIG. 2. THE PENISTONE DISTRICT

ASSOCIATION				Parent Material	Land form	Predominant Soils
A	SWINDEN	Dip-slope and scarp 800-950 ft.	A1	Coarse sandstone	Very gentle dip-slopes	Brown earths (SL)
			A2	Colluvium over shale	Strongly sloping scarps	Complex
B	FULLSHAW	Valley floor and lower slopes 700-1000 ft.	B1	Shale	Gentle slopes	Surface water gleys (SiC)
			B2	Sandstone	Gently sloping ridges	Gleyed brown earths (SL)
			B3	Don alluvium	Level floodplain	Variable - clayey
			B4	Porter alluvium	Level floodplain	Variable - loamy
C	HARTCLIFF	Valley side-slopes 800-1000 ft.	C1	Shales and sandstones	Moderate slopes	Surface water gleys (SiC)) Gleyed brown earths (SiCL))
			C2	Fine sandstone	Gently sloping benches	Gleyed brown earths (SiL)
			C3	Shale	Strongly sloping scarps	Brown earths (SiCL)) Gleyed brown earths (SiCL))
D	LANGSETT	Dip-slope and scarp 800-1200 ft.	D1	Medium sandstone	Very gentle dip-slopes	Brown earths (SL)
			D2	Shale	Gentle slopes	Surface water gleys (SiC)
			D3	Colluvium over shale	Steeply sloping scarps	Complex
E	HOYLAND	Rolling terrain 600-800 ft.	E1	Flaggy sandstone	Very gentle slopes	Gleyed brown earths (SiL-SiCL)
			E2	Shale	Gentle to moderate slopes	Surface water gleys (SiC)
			E3	Colluvium over shale	Strong slopes	Complex
			E4	Don alluvium	Level floodplain	Variable

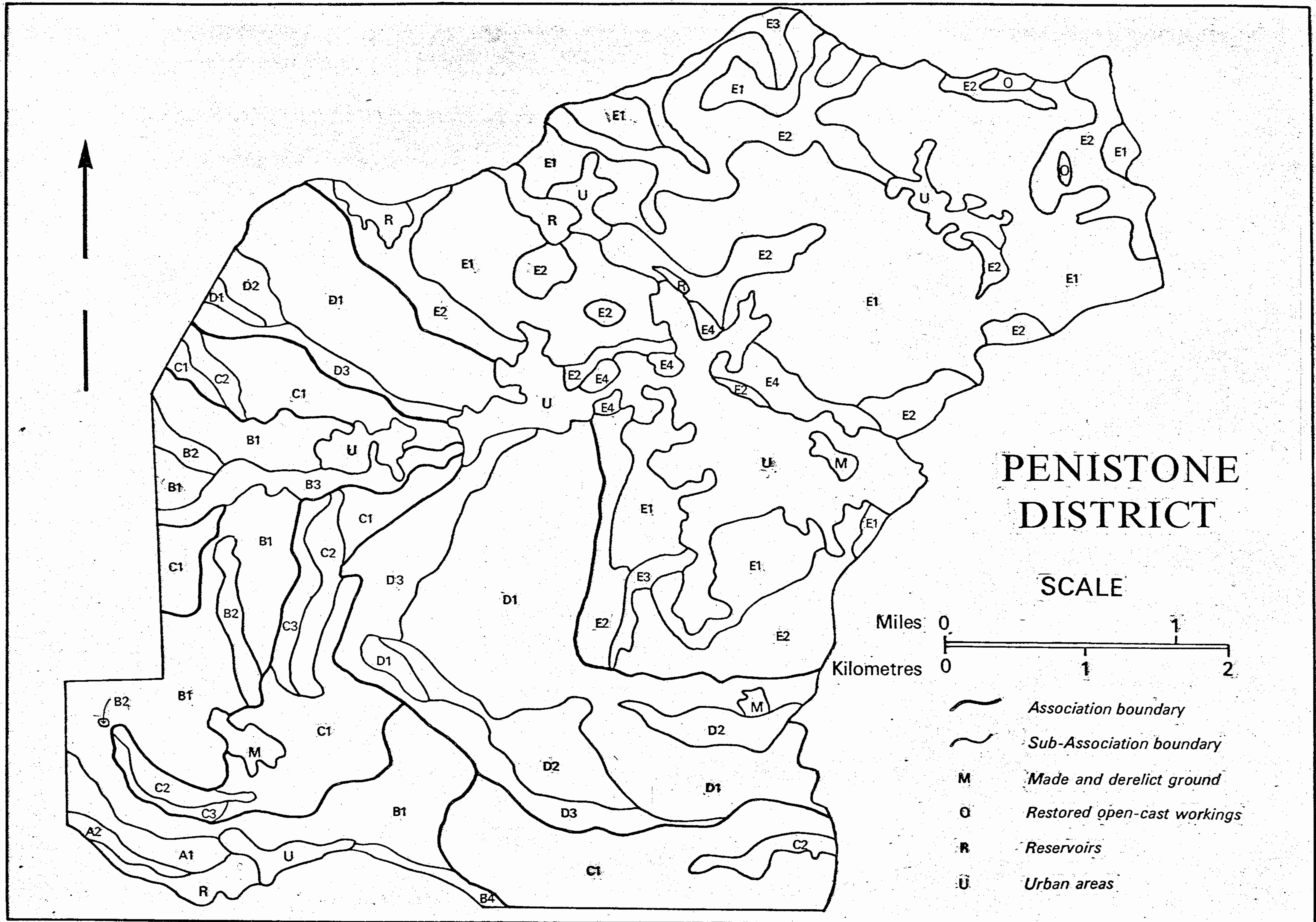
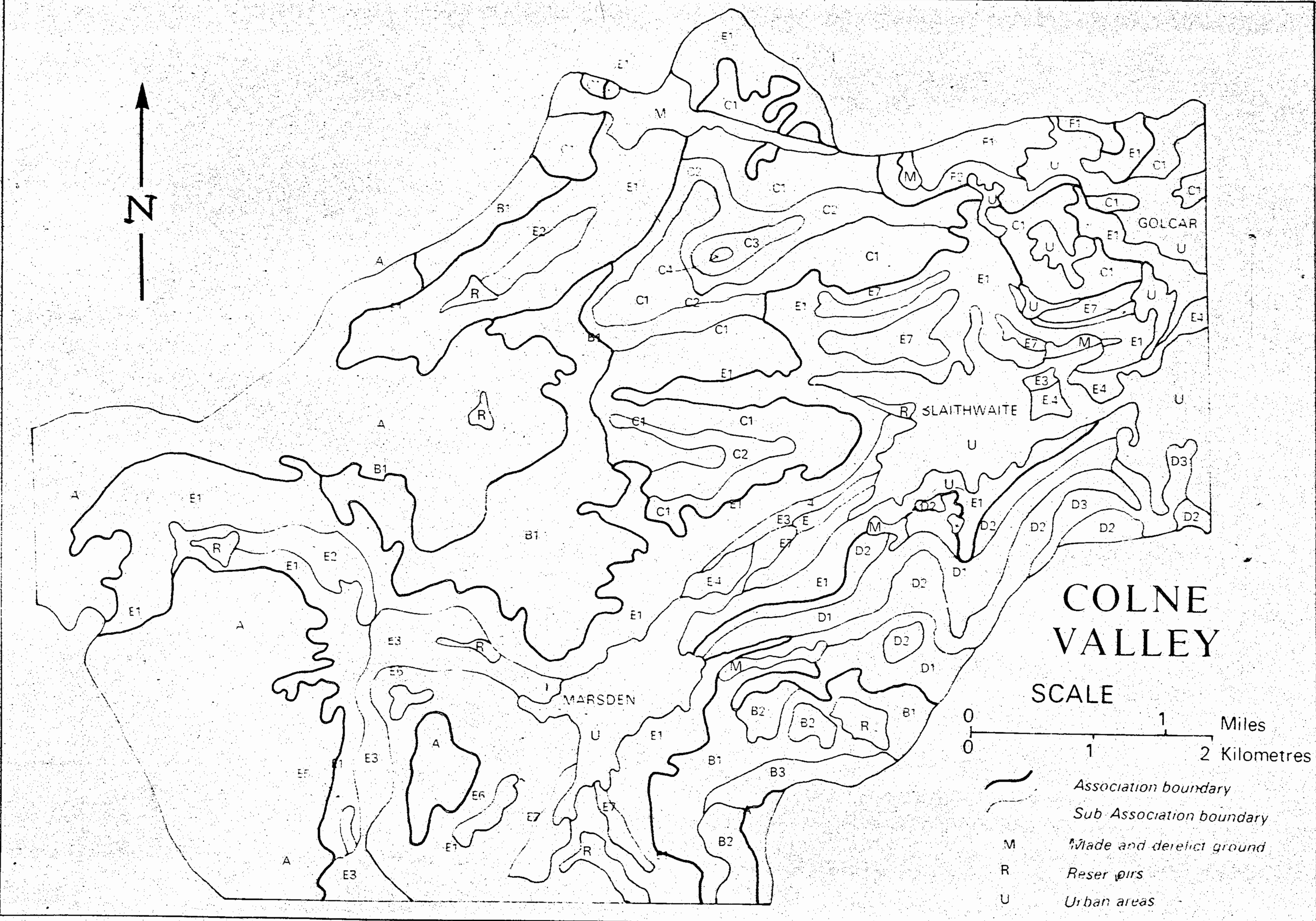

PENISTONE DISTRICT
SCALE
Miles 0 1
Kilometres 0 1 2
Association boundary
Sub-Association boundary
M Made and derelict ground
O Restored open-cast workings
R Reservoirs
U Urban areas

FIG. 3. THE COLNE VALLEY

ASSOCIATION				Parent Material	Land form	Predominant Soils
A	MOSS	Peat moors 1000-1600 ft.	A	Blanket peat	Gentle slopes	Deep peat
B	LINGARDS	Gritstone summits 100-1300 ft.	B1	Sandstone	Gently sloping summits	Peaty gleys with ironpan(SCL)
			B2	Peat over sandstone	Gently sloping summits	Peat and peaty gleys
			B3	Shale	Steeply sloping scarps	Complex
C	MOORSIDE	Rolling gritstone plateau 700-1200 ft.	C1	Fine sandstone	Gentle to moderate slopes	Gleyed brown earths) Peaty gleys with iron pan) (FSL-SCL)
			C2	Shale	Moderate slopes	Peaty and surface water gleys (SiC)) Gleyed brown earths (SiCL))
			C3	Shale	Steeply sloping scarps	Complex
			C4	Coarse sandstone	Very gently sloping summit	Podzols and podzolic brown earths (SL)
D	CHAIN	Stepped valley side-slopes 600-1000 ft.	D1	Shale	Moderate slopes	Surface water gleys, sometimes peaty (SiC)
			D2	Fine sandstone	Gently sloping valley benches	Gleyed brown earths (FSL-SCL)
			D3	Shale	Steep slopes	Gleyed brown earths (SiCL)
E	SCAMMONDEN	Steep valley sides 500-1400 ft.	E1	Colluvium	Steep to very steep slopes	Complex
			E2	Sandstone	Valley floors	Peaty gleys with ironpan (SCL)
			E3	Shale	Lower valley side slopes	Surface water gleys (SiC-SCL)
			E4	Colne alluvium	Level floodplain	Variable
			E5	Peat	Very gentle slopes	Deep peat
			E6	Sandstone	Gently sloping valley benches	Peaty gleys with ironpan(SCL)) Peaty rankers)
			E7	Sandstone	Gently sloping valley benches	Gleyed brown earths (SCL)
F.	WHOLESTONE	Sandstone plateau 1000-1250 ft.	F1	Coarse sandstone	Very gently sloping summit	Podzols and podzolic brown earths (SL)
			F2	Shale	Steeply sloping scarps	Complex



N
MARSDEN
SLAITHWAITE
GOLCAR
COLNE VALLEY
SCALE
0 1 Miles
0 1 2 Kilometres
Association boundary
Sub Association boundary
M Made and derelict ground
R Reservoirs
U Urban areas

in the survey area. It is planned to study a further area in the east to test whether the low-lying shale terrain has as uniform a soil distribution as the photo interpretation suggests.

Field work began in the sample areas in May 1969 and will continue until the end of the year. The validity of the boundaries of the units delineated during photo-analysis are examined by ground traverses, and their component soils identified. Inspection holes are dug at 100 metre intervals along these traverses and more frequently in areas of rapid lateral change. The soil series recognized will be described in detail and samples taken.

After field work, the photographs of the sample areas will be re-examined in the light of the knowledge gained during the survey; boundaries will be re-drawn where necessary and a soil map prepared. The photo-analysis of the remainder of the survey area will then be revised and a legend devised for reconnaissance mapping.

Preliminary results

Although the survey of the sample areas is not yet complete, some preliminary results can be summarized here:

(1)

Most of the boundaries located by photo-analysis were confirmed by later field work. Some, such as the boundary between deep peat and mineral soils, were much more accurate than if they had been located by field-work alone. If the final aim is a map showing soil series, more boundaries would be needed, mainly reflecting differences in soil drainage; some, but not all of these, were identified on stereoscopic re-examination of the photography. Small changes in lithology, such as an unusually sandy shale facies, could not be predicted. Boundaries were somewhat less accurate in the Colne Valley than in the Penistone area, as the wetter climate tends to obscure differences in lithology and topography.

(2)

The survey suggests that, in areas similar to those studied, 15-20 observations per sq. km. suffice to check boundaries and identify soils for a 1/25,000 map produced by photo-interpretation methods. This density can be further reduced in more homogeneous areas, such as gentle slopes covered by deep peat. Even if several days are spent in the preliminary photo-analysis, this represents a considerable saving in field work, which has hitherto required some 30-50 observations per sq. km.

(3)

The main benefit of photo-interpretation is the extrapolation of knowledge gained from sample areas surveyed in detail. For the 1/250,000 County map series, sample areas will be required for each soil association recognized; such sample areas need not be whole 1/25,000 sheets, as are being mapped in the lowlands. Association boundaries could be mapped with a sampling density of only one observation per sq. km., but four to six may be required during routine mapping to check whether constituent series and their inter relationships remain those defined in the sample areas.

(4)

Areas of deep peat can be mapped with a minimum of fieldwork using air photos. Field excursions with Forestry Commission and N.A.A.S. Grassland experts have shown that in many cases the vegetation type and the erosion phases of the peat can be recognized. Within the peat zone, rock outcrops and areas of boulders and scree are clearly visible.

(5)

Additional field investigation is needed to distinguish shallow peat over rock from mineral soils with a peaty surface horizon. In the areas examined, however, these soils rarely occur on the same topographic site and are usually separated by differences in relief.

(6)

Steep sloping valley sides and scarp faces can be delineated very accurately with the aid of air photos. The associated soils, however, can only be distinguished at very large mapping scales and they will be grouped into one or more soil complexes.

(7)

Where the parent rock is shale, a distinction can usually be made between moderately steep land and gentler slopes ($<6^\circ$), separating freely and imperfectly draining brown earths from poorly draining surface water gleys.

(8)

The gently sloping Millstone Grit summits in the Colne Valley are covered by peaty gleys with ironpan, giving a characteristically speckled texture to air photos. Freely draining brown earths in the same physiographic position have a uniform light tone and often land use differences. Variations in soil texture resulting from the different lithology of the various Millstone Grit sandstones cannot be predicted.

(9)

In the Penistone district, flaggy sandstones on irregular, weakly accentuated slopes give rise to imperfectly draining silty soils with a characteristic photo-pattern. They are separated topographically from interbedded shales forming poorly draining clays.

Gentle dip slopes of medium grained sandstone, also in the Penistone district, have a regular photo-pattern, consisting of freely draining brown earths; land use differences indicate areas of podzols and rankers.

FUTURE WORK

Staff

The experience gained during the first year can be extended over a much wider area to form the basis for part of the West Riding County soil map.

If the techniques evolved are to be applied as routine measures, an Assistant Experimental Officer will be needed, as foreseen in a previous paper to the Board[2].

Transferring detail from the photographs to maps with the Sketchmaster has been found to require about 20 per cent of the Scientific Officer's time. Funds for part-time cartographic support have been requested in next year's estimates.

1970 programme

During the winter of 1969 and the spring of 1970, a photo-analysis similar to that described above will be made of the limestone areas of the West Riding Pennines and of Bowland Forest. The effectiveness of photo-interpretation in till covered areas will also be tested. Sample areas will again be chosen and it is hoped that the framework for the routine mapping of most of the upland areas of the West Riding will be completed by the end of 1970.

The first photography specially commissioned for the unit, covering Westmorland and the Pennine portion of the Yorkshire North Riding (panchromatic film, scale 1/20,000), has been partly taken and will be available shortly from the contractors.

Experimental photography

Negotiations have been concluded with an air survey company for aerial photography of the Peak District using colour film processed to the negative stage, from which either black-and-white or colour prints can be made. Colour and panchromatic film will be exposed simultaneously over two sample blocks within the main area and the black and white prints made from both films compared. Colour infra-red ('false-colour') film will also be flown for these sample blocks.

Colour and colour infra-red film will be tested in a drumlin field and in another area, where panchromatic film is of only limited value because of the uniform appearance of its smoothly rolling terrain.

Liaison with other organisations

Recent advances in the use of various films and remote sensing devices in many disciplines are under review. Close liaison will be maintained with the leading British users of experimental photography: the Photo-Geological Division of the Institute of Geological Sciences and the Land Resources Division of the Directorate of Overseas Surveys. Recent work in the Netherlands on combinations of films and filters and the spectral reflectance of soils is being studied. Departments of Leeds, Sheffield, Newcastle, Belfast and Amsterdam Universities have shown interest in the work of the unit and there is continual consultation with the Survey's Lowland Photo-Interpretation Unit and with members of the Scottish Soil Survey, who are working in upland areas with air photographs.

CONCLUSIONS

Given the favourable conditions present in much of Britain, a soil survey aided by systematic photo interpretation can be shown to be quicker than and as accurate as one carried out solely by field-mapping. The saving of time, manpower and expense is in line with the recommendations of a recent Agricultural Research Council Working Party[7] to the effect that soil survey ought to be speeded up and that areas of poorer land and less favourable climate should not be neglected in a research programme.

Photo interpretation methods can effect useful savings at the 1/25,000 scale of mapping. Their greatest value, however, will be in the rapid mapping of upland areas at the 1/250,000 scale, although a modest increase in staff will be needed for this to become a routine measure.

In the past, the introduction of photo-interpretation into soil survey has been prevented by the lack of good working material. High quality photography taken at suitable scales and seasons is a prerequisite for mapping upland soils. Further areas should be flown for the Survey as funds permit until there is complete cover of the uplands of England and Wales. Although panchromatic film is known to be extremely useful for soil survey, the new aerial survey materials and techniques now being developed may be even more useful and they will be evaluated as opportunities arise. Close collaboration with other organisations interested in these topics will be continued.

RECOMMENDATIONS

The Board is invited to consider the progress and plans of the unit, and to support the proposal for recruitment of an Assistant Experimental Officer. Comments and suggestions for improvement will be welcome.

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