ROTHAMSTED RESEARCH

Report for 1976 - Part 1

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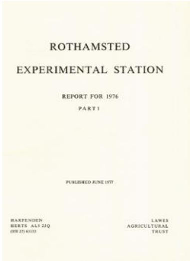
ROTHAMSTED

EXPERIMENTAL STATION

REPORT FOR 1976

PART 1

Soil Survey of England and Wales

K. E. Clare

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SOIL SURVEY OF ENGLAND AND WALES

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Introduction

The period of careful reviewing of the Survey's activity that has characterised the last two or three years showed signs this year of coming to an end and we were able to devote more time and energy to execution as distinct from planning. The soil, drier this year even than last, was distinctly difficult to auger in many southern and eastern parts of the country, but even so surveyors were able to cover more ground in detail than in 1975.

The aims of the Survey continue to be to describe, classify and map the different soils of the two countries. The soils are described in profile, and kinds of profile are differentiated at four succesive categorical levels, termed major group, group, subgroup and soil series. Classes in the three higher categories are defined partly by the composition and mode of origin of the soil material, and partly by the presence or absence of particular horizons, within specified depths, using properties that can be observed or measured in the field or inferred from field examination by comparison with analysed samples. Soil series are distinguished mainly by lithology. When a map unit is identified by the name of a soil series or other class, it is implied that most of the soil in each delineation on a map conforms to that class. More heterogenous units (complexes or associations) are similarly identified by the names of two or more classes.

The properties of the soils shown on maps are described in accompanying publications, as are the geography, geology, climate and land use of the district surveyed. Soil and land use capability maps, with the text, are a permanent record of the distribution and properties of the different kinds of soils.

The mapping programme continues, with the surveying of districts in each county chosen for their geomorphological and agricultural interest, and with the compilation of maps at a scale of 1:25 000; 47 such areas were worked on during the year and some 1045 km^2 were surveyed in detail on 32 of them. Forty-five maps at a scale of 1:25 000 have now been published with explanatory publications—usually *Soil Survey Records*—for 40 of them. In the Northern Region upland areas have continued to be surveyed by field work combined with air photo interpretation for eventual publication at a scale of 1:100 000. Progress in reconnaissance survey also included compilation of maps of soil associations at a scale of 1:250 000 for the counties of Derbyshire, Norfolk and Pembrokeshire.

Northern England

Cumbria

Parts Sheets NY 04/05/14/15 (Abbey Town). A further 60 km^2 were mapped in detail. The soil map has been extended to include an 8 km^2 strip of coastland in Holme St. Cuthbert on Sheet NY 04E, which has stabilised old dunes and raised shingle beaches with raw sands and brown podzolic soils. Marine alluvium south and east of Silloth has gleyic ranker-like alluvial soils and typical alluvial gley soils, similar to those near Longtown (Sheet NY 36/37). The two large NE–SW ridges of the Scottish Readvance moraine have mainly Clifton and Salop soils (1). The long kame ridge north-west of Common Moss has sandy Penrith and Brownrigg soils and smaller areas of the Crannymoor (1) series. There are small patches of indurated gleyic brown podzolic soils (Glassonby series) on all the ridges. The Ousby series is on peat at Common Moss and Salta Moss. (Matthews)

Sheet NY 36 and part NY 37 (Longtown). The *Record* was completed. (Kilgour)

Sheet NY 56 (Brampton). A reconnaissance survey was made, a provisional legend prepared, and 35 km^2 were surveyed in detail.

The area is next to the Northern Pennines and Bewcastle Fells and is some 10 km north-east of Carlisle; Hadrian's Wall, running east–west, divides it.

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Triassic sandstones and shales underlie the western half of the district and the Carboniferous Limestone the eastern half, but aside from a few narrow limestone and sandstone outcrops, the land is covered with superficial deposits. Some 49 km² are over Triassic-derived till, 20 km² on Carboniferous-derived till and Head, 20 km² on glaciofluvial sands, 8 km² on alluvium and 3 km² on peat.

As the last major ice movement was eastward, till derived mainly from Triassic deposits in the west is more widespread than Carboniferous drift from the Pennines. Clifton and Salwick series (1) are widespread, with Lea (1) series less so. The Carboniferous-derived drift is restricted to the higher ground in the south-east and north-east, where the Brickfield and Wilcocks series (1) are the soils most frequently occurring.

Enormous quantities of glaciofluvial sands were deposited during the last ice retreat, extending in a broad belt in the south-west and in the valleys of the Irthing and its tributaries. Newport, Ollerton, Blackwood (2) and Isleham (3) series are in the sandy drifts, the Newport being dominant. Since much of the sand forms steeply sloping eskers, a slope phase of the Newport series has also been mapped.

A raw oligo-fibrous peat soil (Longmoss series) is at Walton Moss. The Irthing alluvium, often with gravel within profile depth, has gleyic and typical brown alluvial soils. (Kilgour)

Humberside

***Sheet SE 85* (*Fridaythorpe*).** Some 15 km² were mapped at Fridaythorpe and Huggate. The soils are mostly brown rendzinas on chalk (Andover (4) series) and paleo-argillic brown earths in plateau drift, resembling the Wold (5) series.

Typical brown calcareous earths in chalky Head (Coombe (4) series) are along shallow depressions and in the bottoms of the steep V-shaped valleys which are common in the district. (R. A. Jarvis and Guardiola Saenz)

***Sheet TA 14* (*Brandesburton*).** Reconnaissance was completed and, following the establishment of a provisional legend, some 30 km² mapped in detail. The legend contains 19 series, 14 of which have been described and sampled. Fine loamy argillic stagnogley soils similar to the Clifton series are widespread on flat and gently sloping areas of the Drab Till with some stagnogleyic argillic brown earths on localised more strongly sloping ground. Although many profiles are reddish at depth, colours within 100 cm of the surface are often brown (7·5 YR) whilst below about 5 m the completely unaltered till is very dark greyish brown (10 YR 3/2). The reddish colour appears to be restricted to a zone of oxidative weathering (Catt, pers. comm.) between 1 and 5 m depth. Correlation with the Clifton series is therefore provisional.

Brown earths and gleyic brown earths similar to the Wick and Arrow series (2) have been recognised in areas of glaciofluvial sand and gravel, with smaller patches of the Newport and Ollerton series. Sandy gley soils (Blackwood series) and cambic gley soils (Quorndon (2) series) occur on lower lying sand and gravel deposits. Organic and alluvial soils are important on the carr land along the western edge of the sheet and include shallow earthy eutro-amorphous peat soils of the Adventurers' (3) series, pelo-alluvial and humic alluvial gley soils.

The long-term leaching effect of rainwater on Drab Till soils is being studied, in collaboration with the Pedology Department, by chemical analysis of drain water samples from a site for which detailed hydrological information is being collected by the University of Hull Geography Department. (Furness)

North Yorkshire

***Sheet SE 39* (*Northallerton*).** The remaining 60 km² were mapped and writing of the *Record* was begun. (Hartnup and Allison)

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Sheet SE 63 & 73 (Selby). The *Record* was completed. (Furness and S. J. King)

Sheet SE 97N/98S (Wykeham Abbey). Reconnaissance was completed and some 45 km² mapped in detail. Pelo-stagnogley soils on glaciolacustrine clay (Foggathorpe (5) series) and earthy eutro-amorphous peat soils (Adventurers' series) are extensive on the floor of the Vale of Pickering and coarse loamy typical brown earths mark the extent of the Wykeham moraine. Grey and brown rendzinas (Upton (4) and Andover series) and typical brown calcareous earths (Coombe series) are on the chalk scarp of the Wolds. The Middle Oolite of the North York Moors carries brown rendzinas (Murton (6) series), fine loamy typical brown earths (Dundale (6) series) and coarse loamy typical argillic brown earths (Fyfield (6) series). (S. J. King)

Northumberland

Sheet NZ 07 (Stamfordham). The *Record* was completed. (George)

South and West Yorkshire

County map. The *Bulletin* was completed. (R. A. Jarvis, Carroll and Hartnup)

Upland maps (1:100 000)

North York Moors. A text to accompany the 1:100 000 soil map was completed. (Carroll and Bendelow)

North-Central Pennines. The area, originally confined to North Yorkshire, has been extended to include parts of Cumbria and Durham. Some 350 km² in Wensleydale and Swaledale were mapped by reconnaissance survey. No new series were recognised. (Carroll and Bendelow)

East Anglia

Cambridgeshire

Sheet TL 34 (Royston). About 14 km² were mapped during initial reconnaissance. The map extends northwards from the chalk exposures around Royston across the terrace deposits of the Cam or Rhee to include soils on Gault clay in the north and small areas on boulder clay in the north-west near Croydon. (Seale)

Sheet TL 39 (Benwick). Some work has been done on this fenland sheet much of which is covered by Chatteris, Downholland and the shallow phase of the Adverturers' series (3) on the Fen Clay identifiable from aerial photographs with the minimum of ground checking. (Seale)

Sheet TL 54 (Linton). About 35 km² were mapped in detail. A recurring catenary sequence has Ragdale (7) series on the narrow flat plateau between Linton and Saffron Walden with a variant of the Hanslope (3) series, calcareous soils mottled above 40 cm on boulder clay, Hanslope series with mottling commencing below 40 cm and Stretham (8) descending in the sequence. There is a small area of shallow phases over chalk of the latter two soils. Soils in the valleys of the boulder clay country are mainly brown calcareous earths, Dullingham (8) series where fine loamy and Stretham where clayey (here on Head from boulder clay). Around the plateau edge clayey, fine loamy and coarse loamy (Newmarket (8)) rendzinas occur on the Middle and Upper Chalk. Varying depths of loams and sands over chalky drift and chalk give Swaffham Prior, Soham, an unnamed deep coarse loamy typical argillic brown earth, Moulton and occasionally Freckenham

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series (8) over chalklands not covered by boulder clay. Reddish brown soils, possibly paleo-argillic, consisting of varying depths of clay, usually over Chalky Boulder Clay, commonly occur around the edge of the boulder clay upland. Fine silty and clayey (Thames (9) series) calcareous alluvial gley soils occur beside the Cam and Granta. (Burton)

Norfolk

Sheets TF 60/61 (Downham Market/King's Lynn South). Following aerial photographic interpretation, approximately 10 km^2 of field mapping has been completed. Much of this work has been concerned with checking boundaries drawn for the 1:250 000 county map of Norfolk.

Soil series mappable at 1:25 000 will include the Ragdale series on Chalky Boulder Clay, Freckenham and Worlington (8) series with a possible new series on sands over shattered ferruginous sandstone (carstone). (Eldridge)

Sheet TG 11 (Attlebridge). Some revision has been made on this sheet. Part of the soil legend is under review with regard to the argillic nature of some soils. The land use capability legend has also been revised in consultation with ADAS.

Areas with aeolian fine sand within the profile also have been delineated on the soil map. These soils intergrade between the Freckenham series on medium sand to the Naburn (10) series on fine sand. (Eldridge)

Sheet TL 99 (Caston). A land use capability map and legend have been drawn up, but further work awaits confirmation of the soil map legend. (Eldridge)

County map. This map has been completed. During the year sheets TF 50, 51 and 52 and parts of sheets TF 40 and 41 in west Norfolk, and in east Norfolk sheets TG 10, 12, 21, 23, 30, 32, 41 and TM 29 were mapped by extrapolation of boundaries from the adjoining sheets and the boundaries checked in the field. A reconnaissance of sheet TG 40 was made by Eldridge.

In west Norfolk most of the soils encountered had been previously recognised. However, a previously unrecorded fine loamy gleyic brown alluvial soil, non-calcareous above 40 cm is widespread to the west and south-west of King's Lynn. On lower land near old river courses unnamed coarse loamy and clayey alluvial gley soils were also recorded.

Maps of the county at 1 to 100 000 and 1:250 000 have been prepared from photographic reductions of the 1:25 000 soil maps. A preliminary legend has been drawn up, to be completed later with information from eighteen profiles mainly in new soils in west Norfolk. (Corbett)

Suffolk

Sheet TL 76E/86W (Risby). Fifteen profiles were examined and sampled near Barrow, Flempton and Bury St. Edmunds to supplement the profiles already available. (Seale)

East Midlands

Derbyshire

County map. Work continued during the spring and early summer on detailed mapping of sample farms in areas for which there is little existing soil information.

In Edale, Brickfield, Bardsey and Hallsworth series (11) dominated lower slopes with soils resembling Alton (11) series on middle slopes over Mam Tor shales.

The Chatsworth district is dominated by brown earths (Swindon Bank (7) series) and

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unnamed brown rankers on Millstone Grit sandstone. Intervening shale bands commonly have soils of the Bardsey series.

In south Derbyshire, reddish till and glaciofluvial drifts over Triassic and Carboniferous rocks form mainly familiar Midland soil associations dominated by Salop, Worcester and Brockhurst series (7).

A total of 16 km² of detailed (1:10 560) mapping was completed. (Reeve and Thomasson)

Lincolnshire

Sheet SK 99 (Kirton-in-Lindsey). About 40 km² were surveyed in detail. The land west of the limestone 'cliff' is mostly till-covered, with pelo- and typical stagnogley soils of the Ragdale and Beccles series (3), and calcareous pelosols of the Hanslope (3) series common. A Ragdale-Hanslope intergrade with gleyed chalky till within 40 cm depth is quite widespread and could be the result of levelling of ridge and furrow systems which are well-preserved under surrounding grassland. Pelo-stagnogley soils of the Crewe series and the stagnogleyic Flint series (2) occur on small patches of reddish till and pelo-stagnogley soils of the Elkington series on reddish chalky till. In contrast to other districts in the East Midlands the reddish till overlies the grey chalky till. In some parts a ridge of Middle Lias marlstone is exposed near the foot of the scarp, with deep fine loamy ferritic brown earths similar to the Banbury (12) series but much less stony. Between this outcrop and the scarp the Upper Lias clay is exposed with pelo- and cambic stagnogley soils of the Long Load and Rowsham series (12) dominant.

The scarp has Northampton Sand and various facies of the Lower Estuarine Series with a complex range of soils including ferritic brown earths of the Tadmarton series.

Many different limestones outcrop on the Inferior Oolite dipslope but fine loamy brown rendzinas of the Sherborne (12) series on plateaux or ridges, and fine loamy brown calcareous earths of the Grange series in dry valleys are the dominant soil types. Three stoniness phases of the Sherborne series are being considered and sampling under way to establish whether the large sand content of the soils is from drift or limestone residium. Also on the dipslope are coarse loamy brown rendzinas of the Rauceby series and unnamed fine loamy brown rendzinas on grey marls of the Kirton Cementstones. Typical argillic brown earths similar to the Tetbury (13) series occur in deep loamy drift on limestone to the east. On the eastern edge of the district there are areas of blown sand with gleyic brown sands similar to the Kexby (5) series and sandy gley soils of the Everingham (5) series. (Heaven)

Sheet TF 39 (Covenham). Some 30 km² of the area were mapped. The typical stagnogley soils on reddish Devensian till have fairly uniform fine loamy to clayey subsoil horizons but variation in topsoil particle-size class causes significant differences in the date when spring cultivations can begin. The uniform subsoil conditions are reflected in the use of a standard drainage design over large parts of the district. (George)

Sheet TF 45 (Friskney). About 30 km² were mapped in detail. Pelo-calcareous alluvial gley soils similar to the Newchurch (14) series occur on marine alluvium west (landward) of Wainfleet and are locally over thin peat. Fine silty calcareous alluvial gley soils of the Agney (14) series are on low creek ridges. Soil boundaries in this part of the district can be sharp and old fen banks often mark the change from coarse silty to very clayey soils.

The normal intricate fen soil pattern is further complicated in parts of East Fen where there are many buried soils. Here, humose clayey or silty soils similar to Downholland and Blankney series (3) are over clayey or silty humic alluvial gley soils. In parts of East-

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ville brown and grey mottled chalky Devensian till occurs within 80 cm depth under thin clayey or silty alluvium. (Robson)

Northamptonshire

Sheet SP 66 (Long Buckby). Additional samples were taken of soils on ferruginous parent materials to improve the map legend. Soils in which subsoil colours suggested unusually large iron contents had dithionite-extractable iron (as Fe) to clay ratios exceeding 0·35, i.e. Fe_2O_3/clay > 0·5. Tadmarton and Banbury soils were therefore classified as ferritic brown earths. On glaciofluvial sands and gravels, the Sutton and Dodford series were separated; the latter is characterised by loamy-ferruginous horizons over ironstone-rich drift. (Reeve)

Nottinghamshire

Sheet SK 78N/79S (Gringley on the Hill). Some 50 km² were mapped in detail. The physiographic regions of the district include a low undulating plateau of Keuper Marl, the valley of the Idle with extensive alluvial deposits (carr land) and part of the Trent valley with alluvial and warp deposits.

Over Keuper Marl, pelosols of the Worcester series and pelo-stagnogley soils of the Spetchley series (2) are common. Smaller areas of Whimple, Brockhurst and Dunnington Heath series (2) occur where the marl has a cover of loamy drift.

The lowlands are very complex but include large tracts of alluvial gley soils in reddish clayey alluvium. Where the alluvium is more than 80 cm thick the Compton (2) series is mapped; where peat occurs at shallow depth the Midelney (2) series is identified; and where the alluvium is thin over sandy or coarse loamy layers the Stixwould (3) series is found. The soil pattern is further complicated by superficial organic accumulations giving Adventurers' and Isleham series (3).

East of the Idle the Bunter Pebble Beds are mainly obscured by sandy drift. The Blackwood (3) series is common in this low-lying land with groundwater at shallow depth.

Field mapping was hindered by extremely dry conditions in August and prolonged rain in September and October (225 mm). The dry summer caused impressive cracking on clay land, particularly on Midelney soils which also developed a markedly uneven surface due to differential shrinkage, because of the varying thickness and depth of peat layers. Most arable land in the district reached field capacity by mid-October making harvesting root crops difficult on all but the best drained land. (Reeve and Thomasson)

Western Midlands

Hereford and Worcester

Sheets SO 85/95 (Worcester/Upton Snodsbury). The remaining 35 km² of Sheet SO 85 have been completed and the survey is being extended eastward to include Sheet SO 95 (Upton Snodsbury) of which 25 km² have been mapped. Most of SO 95 is over Lower Lias clay shales, clays and mudstones. Keuper Marl occurs in the north-west and south-east and there is a similar soil pattern to that of the eastern half of SO 85. On the Keuper outcrop, Whimple and Brockhurst soils (2) with fine loamy or fine silty horizons over clayey Keuper Marl are most extensive but Worcester and Spetchley soils (2) predominate where it is drift-free.

A provisional legend has been constructed containing 44 soil series and correlation of the Lias soils with those in other regions has begun. Tea Green Marl and Rhaetic rocks occur along a narrow outcrop forming the prominent NE–SW trending, westward facing, scarp from east of Oddingley to near Sneachill. The scarp up to 35 m high separates the low-lying land of the Keuper Marl to the west, from the Lias clays and shales to the east.

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Although small in extent the Tea Green Marl and Rhaetic outcrops give distinctive soils of the Hurcot (13) and the Sinfin (7) series together with soils closely resembling Denchworth and Rowsham series (13) which are also extensive on the nearby Lias rocks.

The Bow Brook, draining southwards from the Birmingham Plateau to join the Avon near Pershore, has formed a broad shallow valley in Lias rocks which is partly filled with reddish drift deposits. Around Lower Crowle and Huddington these form terrace flats about 3 m above the floodplain giving Arrow (2) and similar, possibly argillic, soils. Higher above the stream more dissected reddish fine loamy (sandy clay loam) and clayey (sandy clay) drifts in some ways resembling till, are found. These give stagnogleyic argillic brown earths and typical stagnogley soils similar to the Salop and Salwick series (7). The deposits are somewhat sorted, containing 30–40% clay and have much medium sand. The included stones are large Bunter quartzites with subsidiary sandstones and siltstones and very occasional flints. Sometimes Lias material, including siltstones and limestones, has been incorporated into the base of these deposits, often giving a calcareous matrix. Where the thin drift is over Lias clay within profile depth, cambic stagnogley soils of the Rowsham series and stagnogleyic brown earths of the Podimore (13) series occur.

Evesham (13) and Denchworth soils dominate the drift-free tracks of the Lias outcrop but around Froxmere calcareous soils otherwise similar to the Denchworth series are found. (Palmer)

Salop/Staffordshire

Sheet SO 79E/89W (Claverley). The soil map was prepared for publication, the *Record* written, and a land use capability legend constructed. Physical properties determined for the representative profiles have been used to assess the practical problems associated with droughtiness, poaching, the timing of cultivations and the slaking, capping and compaction of surface horizons for the various map units. A table summarizing the results has been compiled, showing the suitability of soils for the more common agricultural crops in the Claverley district. (Hollis)

Staffordshire

Sheets SK 00/10 (Brownhills/Lichfield). These two sheets, on the north-eastern fringe of the West Midlands conurbation, were chosen in consultation with ADAS. A brief reconnaissance survey was carried out to determine the major soil parent materials.

The eastern half of Sheet SK 00 (Brownhills) covers part of the South Staffordshire Coalfield and has much urban and disturbed land. It is mainly over Middle and Upper Coal Measures but west of Aldridge, there is a small outcrop of Silurian shales and limestones. The solid formations are, however, almost totally covered by reddish 'Irish Sea' drift deposits and soils of the Salop, Clifton, Newport and Wick series (2) predominate. The South Staffordshire Coalfield plateau is bounded on the east by a low ridge capped with Bunter Pebble Beds. This forms some of the highest ground in the district reaching over 183 m (600 ft) near Druids Heath. Bunter Pebble Beds also outcrop on Sheet SK 10 (Lichfield) where, with the Hopwas Breccia, also of Triassic age, they form a deeply dissected ridge running from Hopwas Woods to Weeford Park, broken by the Bourne Brook at Hints. The Bunter Pebble Beds ridges are dominated by soils of the Newport and Bridgnorth (13) series. Between the Pebble Beds outcrops is a broad vale floored by reddish sandstones of Keuper and Upper Bunter age, which give soils mainly of the Bromsgrove (7) and Bridgnorth series, or the Newport and Wick series where there is thin drift. Small isolated patches of till give Clifton or Salop soils. East of the Hopwas–Weeford Park ridge, the Keuper Marl outcrops, but again this is partly obscured by drift deposits, giving Brockhurst, Whimple, Salop or Clifton soils.

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Drainage is mainly to the east by the Bourne Brook and several minor streams which flow into the Tame. This enters the district at Tamworth and flows due north, occupying a broad shallow valley, bordered by extensive low terraces on which Quorndon (2) and Arrow soils predominate. The upper reaches of the Bourne Brook and its tributaries are also fringed by low terraces. (Hollis)

Sheets SK 02/12 (Abbot's Bromley/Draycott in the Clay). The remaining 25 km² of Sheet SK 12 and 20 km² on SK 02 were mapped in detail and representative soil profiles sampled.

The south-eastern quarter of Sheet SK 12 is covered mainly by reddish till giving typical stagnogley soils of the Salop series and pelo-stagnogley soils of the Crewe (2) series. Occasionally brownish till, related to the Chalky Boulder Clay glaciation, gives stagnogley soils correlated with the Ragdale (7) series. Moderately stony phases of the Flint (2) and Salop series have been mapped south of Bentilee Park.

Rhaetic beds outcropping in the west of Bagots Park give fine loamy or fine silty over clayey stagnogley soils that have provisionally been mapped as Marchington series. Micromorphological studies have shown these soils to be argillic and they could eventually be correlated with the Rowsham (13) series.

In Marchington, north of the Rhaetic scarp, typical stagnogley soils of the Brockhurst series predominate, broken only by small patches of Whimple, Worcester and Spetchley soils.

The winter of 1975/76 was mild and dry and stock were grazed in the fields until early or mid February with little or no poaching even on heavy impermeable soils. Some soils did not reach field capacity at any time during the winter. Spring sown cereals germinated poorly because of lack of rain but winter sown crops were growing vigorously by early April.

The Rhaetic plateau extends westwards across Sheet SK 02 as far as Abbot's Bromley. Some small streams rise near the crest of the plateau in Bagots Park and drain into the Blythe which runs through the middle of the area. Further west the Bourne Brook flows from NW–SE to join the Trent.

The rest of the area is mainly over reddish Keuper Marl which is covered by till and glacial sands and gravels probably of Wolstonian age. The Bunter Pebble Beds of Cannock Chase form a steep bluff on the south side of the Trent valley near Wolseley.

The Rhaetic beds in Bagots Park include olive basal sandstones, black shales, brownish and greyish sandy and silty shales and greyish and brownish clays. Where the beds are drift free, Denchworth, Lawford and Marchington soils have been mapped. Below the Rhaetic deposits, Tea Green Marl and red Keuper Marl are exposed giving soils of the Hurcot, Sinfin and Worcester series, whilst at the foot of the scarp thin drift covers Keuper Marl giving Brockhurst soils.

A large spread of sand and gravel extends from Kingstone through Bagots Bromley to Yeatsall on which moderately stony coarse loamy soils of the Wick, Arrow and Quorndon series have been mapped. These deposits also support fine loamy typical brown earths as yet unnamed and fine loamy gleyic brown earths provisionally correlated with the Hopsford series.

On Forge Farm pelo-stagnogley soils on dark brown till have been mapped as Ragdale series. No chalk fragments have been observed and in many profiles the till is decalcified to a depth of 1 m but the material is otherwise similar to Chalky Boulder Clay found near Hanbury.

In the Blythe valley, brownish or greyish river alluvium, variable in thickness (30–90 cm), is over gravel. (Jones)

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Warwickshire

Sheet SP 29 & 39 (Nuneaton). The remaining 80 km² were mapped in detail, mainly on the Cambrian outcrop between Nuneaton and Merevale and in the Keuper lowland of the Anker valley in Leicestershire.

Along the narrow Cambrian outcrop, soils are similar to those on Palaeozoic sediments in Wales. Shallow rankers of the Bangor and Powys series (15) have been recognised and mapped along the crests of the many camptonite intrusions in the shales. Brown earths on these rocks show incipient podzolisation in the pyrophosphate-extractable Fe and Al peaks of their B horizons, which do not, however, meet the requirements of a podzolic B horizon.

Two new soils are defined on the shales. Fine loamy argillic brown earths called Oldbury series occur on the steep slopes mainly in the partly metamorphosed rocks surrounding the intrusions, and more extensively fine loamy stagnogleyic argillic brown earths of the Merevale series occur on less steeply sloping ground. These soils appear to have well defined Bt horizons, although this has yet to be confirmed by thin sections, and both series are distinguished by their fine loamy profiles from the silty Halesend and Yeld series as defined in the Malvern district (16). Some fine loamy typical stagnogley soils have also been recognised, but have not been mapped separately, or given a series name.

The broken relief has made mapping difficult; the soils on the intrusive rocks have been mapped as a composite unit of rankers and loamy-skeletal brown earths, and the shale outcrop, whilst mainly giving Oldbury and Merevale soils, includes also some pelo-stagnogley soils of the Speller (16) series.

The Keuper lowland and the Anker valley north-east of the Warwickshire Coalfield include a wide range of soils that have been described in other parts of the Western Midlands. The red clayey alluvium along the Anker floodplain has Compton (2) soils, and the valleys east of Nuneaton contain grey alluvium from Jurassic rocks giving Fladbury (7) soils, which are often shallow over gravels. The terraces along the Anker have Wick and Arrow soils and upslope from these, large tracts of Whimple soils with fine loamy over clayey profiles occur. Shallow clayey Worcester soils occur on convex slopes where the Keuper Marl has been dissected, and together Whimple and Worcester soils occupy most of Witherley and Caldecote and an area around Nuneaton.

In the north-east, around Higham-on-the-Hill and Stoke Golding reddish till and lacustrine clays give Flint and Salop soils and Chalky Boulder Clay between Hinckley has clayey Ragdale series and the typical stagnogley soils of the Beccles (3) series.

Bardsey (7) series with fine loamy over clayey profiles is mapped over the Lower Coal Measures in Grendon and at Kingsbury the micaceous sandstones of the Haunchwood Beds (Upper Coal Measures) support Rivington and Melbourne soils (7).

Samples from topsoils of arable and grassland fields of some of the more important soils are being tested to compare the ped/fragment stability when wetted and the clay mineralogy of most profiles sampled is being studied. (Whitfield and Beard)

South-east England

Berkshire

County map. The map and *Bulletin* were completed. Numerical analyses of the data was continued on the Rothamsted computer. (M. G. Jarvis)

Essex

Sheet TL 71 (Little Waltham). The remaining 55 km² were mapped, and a soil map, land use capability map and *Record* prepared.

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The more widespread soils in till or Head on plateaux are now broadly defined as follows:

Oak: paleo-argillic stagnogley soil; flinty loamy or silty over clayey.
Hornbeam: stagnogleyic paleo-argillic brown earth; flinty loamy or silty over clayey.
Bengeo: typical paleo-argillic brown earth; flinty loamy or silty over clayey.
Essendon: paleo-argillic stagnogley soil in flinty loamy over stony red mottled clay.
Faulkbourne: argillic pelosol; Chalky till (Chalky Boulder Clay).
Hanslope: calcareous pelosol; Chalky till (Chalky Boulder Clay).

On valley sides, stony fine loamy typical paleo-argillic brown earths in Head are recognised as Terling series, and similar gleyic argillic brown earths as Chelmer (12) series. Coarse loamy brown earths in Head are distinguished as the Rockland series. Measurements of stone volumes in these soils in Head indicate that skeletal variants ($>35\%$ by volume of stones) occur; these soils give poor yields of crops in patches within fields in dry years. (Allen and Sturdy)

***Sheet TM 12* (*Weeley*).** A soil map, land use capability map and *Record* were prepared. (Sturdy and Allen)

Kent

County map. The *Bulletin* has been revised and completed. Forty-three principal soil series are described and defined; brief identifications introduce descriptions of each of the twenty-four map units. Land use capability, winter rain acceptance, soil water regime and ease of cultivation have been tabulated, the whole forming a basis for future detailed applications in Kent.

***Sheet TQ46* (*Paddock Wood*).** A further 25 km^2 have been mapped, chiefly soils in lithologically variable Head and fluvial deposits associated with the Medway.

Most land slopes gently over an impermeable Weald Clay substrate which gives different degrees of seasonal wetness. Least affected are silty argillic brown earths (Hamble (17) series) in thick brickearth 6–12 m above floodplain level between Hadlow and East Peckham and in some lower spreads nearer the rivers. Clayey pelo-alluvial gley soils (Fladbury (17) series) dominate the Medway and Bourne floodplains.

A range of gleyic to stagnogley soils are in Head over Weald Clay. Silty gleyic argillic brown earths (Hook (17) series) in brickearth and typical stagnogley soils in variably stony loam over clay are most widespread, the latter typically on low interfluves. Silty argillic gley soils (Park Gate (17) series) are also extensive, locally with substrata of strongly cemented ferrimanganiferous gravel up to 30 cm thick.

Deep occasionally wet flinty silty soils developed in Terrace 1 deposits are patchy and close to the floodplain near East Peckham. Scattered Terrace 2 deposits about 9 m higher, chiefly near Hadlow, include seldom or occasionally wet loamy soils, with hard, partly-cemented subsoils which impede vertical water movement and restrict rooting depth. (Fordham and Green)

Oxfordshire

***Sheet SP 30* (*Witney South*).** The map has been compiled and the *Record* is being written.

***Parts Sheets SP 33/34/43/44* (*Banbury*).** This area originally surveyed by G. R. Clarke and R. R. Storrier (18) is being re-examined for publication. Six representative profiles were described and sampled and the original series correlated with later mapping.

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***Sheet SP 60* (*Tiddington*).** A further 45 km² were surveyed. The areas mapped were chiefly on Lower Greensand and Portland rocks, and the soils brown calcareous earths, argillic brown earths, brown earths, and rendzinas similar to soils mapped elsewhere as Sherborne (9), Fyfield (9), Shrivenham (9) and Aylesbury (19) series. These materials are very variable and the soils consequently difficult to map, contrasting sharply with the simple patterns of alluvial gley soils and stagnogley soils which dominate the north-west and south-east of the sheet. The dry year has meant that the clayey soils, especially those in recent alluvium or Gault clay, cracked strongly and cracks remained open from 1975 through into the summer of 1976. (Hazelden)

South-west England

Cornwall

***Sheet SW 53* (*Hayle*).** The *Record*, soil map and land capability map were completed.

***Sheet SW 61, 62, 71 & 72* (*Lizard*).** Reconnaissance was completed and 55 km² mapped. The proline corer revealed up to 3 m of loess on parts of the serpentine outcrop near the coast at Coverack, whilst cores 3 m deep have been obtained of deeply weathered *in situ* gabbro. Water levels are being monitored in some of the soils with gley morphology to establish their water regimes. (Staines)

Devon

***Sheet SS 20* (*Holsworthy*).** The *Record*, soil map and land capability map were completed. (Harrod)

***Sheet SS 74/75* (*Lynton*).** In Devon county 70 km² have been mapped over the mainly sandstone Hangman Grits and the slaty Lynton and Ilfracombe Beds. Most of the sheet in Somerset is covered by the Exmoor Forest survey (20) and the two surveys are being correlated.

Above about 300 m there is open moorland on Hangman Grits. Some flat interfluve crests and basins carry peat soils while loamy stagnopodzols and stagnohumic gley soils mantle many of the gentler slopes. Stagnopodzols are widespread, while podzols often occur on steep slopes. In places cultivation or degradation of surface organic matter by swaling (burning) or denshiring (paring and burning) makes the differentiation of these two kinds of podzolic soils more difficult. Coarse loamy soils with brightly coloured sub-surface B horizons occupy most of the very steep slopes close to the valleys. Depending on the results of laboratory analyses these will be classified as brown podzolic soils or brown earths. Closer to the Bristol Channel on enclosed land such soils occupy inter-fluvial crests as well as the steep valley sides. Over the slaty Lynton and Ilfracombe Formations the soils are similar though more often fine loamy, and can be correlated with the Dartington or Highweek series (21). Near the coast the Lyn rivers are sharply incised with valley side slopes often steeper than 30°, as are slopes above the sea cliffs. These slopes have boulders, rocky outcrops and bare scree among soils like those of the nearby ridge crests. Near Foreland Point and north of the Valley of the Rocks ground has been separated on the map, in which scree and bare rock are more widespread and associated with rankers. (Harrod and Hogan)

Gloucestershire

***Sheet SO 61* (*Cinderford*).** An additional 40 km² were mapped, almost completing the forested parts of the area. The contents of pyrophosphate-extractable iron and aluminium indicate that the coarse loamy soils over Pennant Sandstone are often brown

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podzolic in character, not brown earths as was supposed. Soils over sandstone outcrops in the Suprapennant Formation are a rather more variable mixture of brown earths and brown podzolic soils and fine loamy variants of the former. Soils over Suprapennant and Trenchard Shales are dominated by gley morphology and a sharp textural change within the profile. Their uppermost horizons are markedly different under different tree species.

About 5 km² of the area is occupied by Silurian rocks; shales, limestones and siltstones of the Wenlock and Woolhope Formations. Soils on shale are mainly clayey stagnogley soils of the Speller (16) series and fine silty stagnogleyic brown earths of the Yeld (16) series. Limestone soils include a fine silty brown ranker and the siltstones give fine silty brown earths. (Colborne)

***Sheet SO 72* (*Newent*).** A further 45 km² were mapped chiefly around Newent, Upleadon and Taynton.

Variations in the cementation and particle-size class of the Triassic sandstone determines the associated soil pattern. Soils of the Bridgnorth and Bromsgrove series (7) over hard sandstone are mainly on moderately sloping valley sides. On gently sloping interfluves deeply weathered fine or fine over coarse grained soft sandstones and uncemented slightly stony coarse grained sands give intergrades to Newport and Wick series (7); Wick soils in recent sandy loam colluvium occupy the valley bottoms. On some valley sides there are loamy typical argillic brown earths in interbedded marl and soft sandstone. Other typical argillic brown earths in loamy over calcareous sandy Head over river terrace deposits occur on lower valley side benches flanking the river Leadon between Newent and Hartpury.

Soil pattern in the Taynton district is complicated both by the folding and faulting of Devonian and Silurian rocks flanking May Hill, and by the presence of much thin drift from these rocks over Triassic mudstones in the vale below giving wide areas of Brockhurst (7) soils. Soils on Devonian rocks consist mainly of silty Bromyard (16) soils over marls and coarse loamy Eardiston (13) soils over siltstones and fine grained sandstones, with small patches of Netchwood and Middleton soils (13) below spring lines. Yeld and Speller soils occur over siltstones and calcareous mudstones of Llandoverian and Ludlovian age, with Munslow (22) soils over Llandoverian siltstones and parts of the Devonian passage beds. Small lenticular patches of Woolhope Limestone give soils similar to those described in the Wilderhope-Gatley (22) complex. (Cope)

Wales

Clwyd

***Sheet SJ 17* (*Holywell*).** The map and *Record* were completed. A further 90 samples of surface soil were collected for analysis of heavy metal and nutrient contents at the ADAS laboratory, Bangor. (Thompson)

***Sheet SJ 24* (*Llangollen*).** A further 12 km² were mapped mainly in the south of the district. Typical brown podzolic soils of the Manod (15) series occur on the steeply sloping ground south of the Dee, while typical brown earths of the Rheidol (23) series occupy glaciofluvial and river terraces often with small patches of peat soils. On the floodplain and low terraces, silty brown alluvial soils of the Teme (23) series are identified and occasional variants with sandy or gravelly lower horizons; loamy soils of the Wharfe (7) series occur more rarely. Elsewhere, fine silty gleyic brown alluvial Clwyd (23) soils are mapped with some typical alluvial gley soils of the Conway (23) series mainly in local depressions.

Pengwern Vale, a deeply incised and abandoned preglacial meander of the Dee, has

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Tregaron (23) soils in silty alluvium with peaty layers and deep amorphous peat soils in the valley floor. These are bounded by fine silty Cegin (23) soils on moderate slopes extending east into a weakly developed drumlin field blocking the valley exit. (Lea)

Dyfed

***Sheet SN 24* (*Llechryd*).** The remaining 20 km² were mapped and the *Record* is in preparation. A series of pits have been dug in the Irish Sea clay soils, partly in conjunction with the work on stagnogley soils. The results of analysis and micromorphological investigations will establish the presence or absence of argillic horizons and aid correlation. (Bradley)

***Sheet SN 45* (*Llanarth*).** Reconnaissance was begun and 53 profiles described at 1 km intervals. The district represents the dissected plateau of mid-Ceredigion with extensive tracts of Cegin soils associated with slowly permeable drift. Deposits of Irish Sea clay and pingos occur in the valleys to the south of Clettwr and Grannell. (Bradley)

***Sheet SN 62* (*Llandeilo*).** The remaining 13 km² were surveyed and the *Record* prepared. (Wright)

***Sheet SN 72* (*Llangadog*).** Following a reconnaissance, a provisional legend was established and 16 km² mapped in detail. Old Red Sandstone rocks, mainly fine sandstones and siltstones, outcrop over most of the district, passing in the north to Lower Palaeozoic mudstones, sandstones and grits. Small outcrops of the Carboniferous Limestone and Millstone Grit overlie the red rocks in the south-east.

About 70% of the district is above 180 m and 20% higher than 300 m. The land rises from 45 m at Llangadog in the north-west through the mainly subdued relief formed by the Lower Palaeozoic sediments, to the more steeply dissected Old Red Sandstone uplands, reaching 675 m on the mountains in the south-east. A corresponding increase in annual precipitation from 1400 to 2540 mm reflects the altitudinal range.

The soils from Lower Palaeozoic rocks are similar to those on Sheet SN 62 (Llandeilo). Cambic stagnogley soils of the Cegin series are widespread on gentle slopes with typical brown earths of the Denbigh (23) series and typical brown podzolic soils of the Manod series on steeper hills and ridges. An extensive river terrace to the east of Llangadog carries typical brown podzolic soils of the Nefern (15) series.

The soils of the Old Red Sandstone land below 300 m are also similar to those on the adjacent sheet, though the reconnaissance suggests that proportions can differ. Cambic stagnogley soils of the Fforest (24) series and cambic stagnohumic gley soils of the Wenallt (24) series which had a restricted occurrence on Sheet SN 62, form extensive tracts of wet land. Typical brown podzolic soils of the Whitcott series, which were sporadic and unmappable on Sheet SN 62, are widespread on the steep valley sides. On the mountains above 300 m the Wenallt series is the main soil of the footslopes and summits, with ferric stagnopodzols on the steep flanks. Small areas of bare rock with humic rendzinas and humic rankers have been mapped on the Carboniferous Limestone and Millstone Grit. (Wright)

Pembrokeshire. The remaining 80 km² were mapped at 1:25 000 from aerial photographs and an additional 250 km² of earlier drafts were remapped to bring them to the same standard. A hand-coloured reduction to 1:50 000 was completed and an edited 1:250 000 county map prepared. (Rudeforth)

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Powys

Sheet SJ 21 (Arddleen). Reconnaissance has begun with the mapping of 11 km² and the description of 11 soil profiles. Work has centred on the extensive floodplains of the Severn and Vyrnwy which cover 20% of the map and, in particular, on identifying alluvial soils. Typical alluvial gley soils dominate the floodplain of the Severn while similar soils also occur on low-lying terraces of late glacial outwash silts. (Thompson)

Basic research

Physical measurements

Further measurements of soil salinity were made during the summer in the Waveney and Bure floodplains in Norfolk supplementing the work of previous years. A detailed transect related salinity to micro-relief. Information on salinity was supplied to consultants to the proposed Yarmouth barrage. (Eldridge, with H. Fearnett, student worker)

The soil shrinkage study was continued with samples from Halstow, Tedburn, Spetchley, Evesham, Wentlloog, Faulkbourne and Compton profiles as well as further samples from Fladbury and Worcester soils. In addition to the various physical and chemical measurements, the relationship of soil fabric to shrink-swell potential is being examined using thin sections. A preliminary paper discussing the influence of various factors on potential shrinkage is being prepared. (Hall, Reeve and Bullock)

Soil temperature

The work has been concluded and the results are being prepared for publication. (Matthews)

Minor element studies

Pembrokeshire. A paper describing minor element distribution and relationships in north-west Pembrokeshire has been prepared for publication. (Rudeforth and Bradley, with Wilkins, Pedology Department)

Carmarthenshire. In cooperation with ADAS, six major soil series were sampled in the Llandeilo district for analyses of Cu, Co and Mo contents. No abnormal values were found and none would be expected to cause crop or animal disorders. This contrasts with local veterinary experience which has found Cu and Co deficiencies in livestock to be widespread. Investigations will therefore continue in the adjoining Llangadog district (Sheet SN 72) and will be extended to include all the main soil series. Soils and herbage samples will be taken and Se contents also measured. (Wright)

Soil chemistry

Investigations in cooperation with ADAS in the Llandeilo district showed that the phosphate sorption capacity of typical brown podzolic soils of the Manod series was significantly greater than that of five other soil series. This study will be extended to the main soils of the Llangadog district. (Wright)

Organic soils

A paper dealing with the characterisation of peaty materials from organic soils in England and Wales has been submitted for publication. It is concluded from this study on 88 samples from a wide range of profiles that laboratory measurements of (1) 'rubbed' fibre on an ash-free dry weight basis; and (2) absorbance at 550 nm of a pyrophosphate

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extract of undried samples, provide useful indices against which to standardise field assessments of physical properties of peats. A classification diagramme is proposed. (Bascomb, with Banfield, Statistics Department)

Upper Greensand soils

Using a magnetic separator, fine sand fractions (62–212 μm) of seven glauconitic soils were divided into relatively unweathered glauconite *grains*, more weathered glauconitic *aggregates*, and quartz. Amounts in the first two categories were inversely related. Work so far suggests that glauconite weathers *in situ* to form cohesive aggregates of clay-size material which are not easily dispersed or translocated with the profile. The nature of these aggregates is being further investigated.

Two profiles on the Chert Bed facies of south-west England have also been examined. Unlike the seven profiles noted above, these contain little glauconite and appear to have formed in a loess-like superficial deposit. (Loveland)

Clayey soils

Data are being accumulated whereby clayey soils (containing more than 35% clay <2 μm) of similar morphology can be classified according to their composition and behaviour rather than on an inferred parent-material (litho-stratigraphic) basis. The USDA classification uses coefficients of linear extensibility (COLE) and clay mineralogy classes for this purpose, and the feasibility of applying similar criteria in England and Wales has been assessed with particular reference to the clayey soils derived more or less directly from argillaceous rocks of pre-Quaternary age. Cation exchange capacity (CEC), non-exchangeable K_2O and X-ray diffraction data on clay separates from B horizons of 102 profiles representing established soil series on formations ranging from Eocene to Silurian have been used to place the soils in mineralogy classes (25). COLE determinations have been made with clod samples from soils of several of the series and related to clay content and CEC.

The results show that, whereas clays from Paleozoic and Permo-Triassic rocks are mainly micaceous or 'mixed' and those from younger rocks mainly smectitic, there are important exceptions to this rule, exemplified by Long Load soils on certain Jurassic clays. As intraformational variability in clay mineralogy is apparently at least as great as interformational variability, certain soil series now distinguished litho-stratigraphically could evidently be grouped mineralogically, whereas others appear heterogeneous. In 17 subsurface horizons examined, COLE is closely correlated ($r=0{\cdot}92$) with CEC of the clay fraction expressed on a <2 mm basis. This supports Schafer and Singer's (26) finding that shrink-swell potential is mainly determined by the proportion of expansible clay-mineral layers in the soil as a whole. It is concluded that division of clayey soil subgroups (pelosols and pelo-subgroups) into two classes defined by limiting values of COLE or CEC would be useful and practicable and could supplement soil series separations based on litho-stratigraphy. (Avery, Bullock, Hall and Reeve)

Brown podzolic soils

Chemical and mineralogical analyses have shown that clay fractions of freely drained soils currently identified as brown podzolic contain significant amounts of amorphous aluminosilicates resembling allophane. Samples from 32 more podzolic B horizons have now been analysed, using fluoride reactivity, acid-oxalate extraction and selective dissolution with NaOH to estimate amorphous constituents. The results confirm the earlier findings and indicate a general relationship between content of amorphous Al and parent rock in the order: basic igneous > acid igneous > pelitic sediments > sandy sediments.

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They also support the conclusion of Perrott *et al.* (27) that fluoride reactivity is closely related to amounts of poorly ordered aluminous material and could serve as a readily determinable index value for use in soil classification. (Loveland)

Paleosols

A temporary section at Springfield, Essex (TL 725085) showed that Boulder Clay (Springfield Till) lacked chalk stones and appeared to be weathered to between 2 and 3 m below the surface, with shallow spreads of stony loamy and clayey material above, often channelled into the till. Rubification (colours of 2·5 YR or redder) was most intense in thick loamy superficial material, but was also seen in the top part of the weathered clay where the loamy cover was thin. Samples were taken at close vertical intervals from areas of thick red loamy drift, and thin loamy drift over slightly reddened clay, representing profiles of Essendon and Oak series respectively.

Particle-size distribution and clay mineralogy were determined, and study of micromorphology and sand and silt mineralogy are in progress. (Allen, Bullock and Sturdy, with Catt, Pedology Department and Miss S. Greenfield, student worker)

Cover Loam and Sand

The investigation into the boundaries of the Cover Loam area of north-east Norfolk has been completed and a map prepared showing the distribution together with diagrammes of the local variation on high ground.

Previous work on short distance variation in drift, largely derived from Cover Sand, over boulder clay (Beccles series) has been repeated to establish reliability in using a grid of bores as a basis for assessing field drainage recommendations. (Corbett)

Methodological research

Micromorphometry

Voids have been measured and characterised in 54 soil thin sections from ten profiles, using the image analysing computer (Quantimet). Two papers describing the methodology have been prepared. Basic measurements of voids now made by Quantimet include area, perimeter, full feature and end feature counts, horizontal and vertical projections, and horizontal and vertical Feret diameters. Effort has been directed to using these measurements for characterising the tortuosity and orientation of voids.

Two facets of tortuosity can be determined. One is a measure of digitation, which reflects the length of finger-like protuberances, and the other a measure of the density of marginal crenulations or serrations. Digitation is obtained from the horizontal and vertical projected lengths and Feret diameters, and crenulation or serration from the full count and end count measurements.

The orientation of voids in thin sections can be sensitively portrayed by horizontal and vertical Feret diameter measurements at 10° intervals during rotation of the section through 90°. (Bullock, C. P. Murphy and Biswell)

Soil classification

Morphological and chemical criteria for identifying podzolic soils (Spodosols) have been reviewed, with particular reference to upland soils of transitional character classed as brown podzolic soils and stagnopodzols by Avery (28). Existing data on these soils were collated, and their placement in the USDA System and other current classification schemes examined. It is concluded that:

1. Observations in Britain indicate that the colour requirements of the spodic horizon exclude some soils otherwise identifiable as Spodosols.

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2. Micromorphological criteria for podzolic or spodic B horizons involving recognition of pellet-like micro-aggregates are insufficiently precise to serve as effective means of identification in borderline cases, and may not have the significance intended.
3. The chemical criteria for the spodic horizon seem unduly restrictive insofar as some B horizons identifiable as spodic by morphology do not meet them. Conversely, those for the podzolic B horizon in the English and Canadian classifications permit inclusion of non-illuvial B horizons resembling those of Andepts (Andosols).
4. Placic horizons evidently include more than one kind of horizon, only one of which corresponds to the thin ironpan as conceived in Britain.
5. While the separation of brown earths, brown podzolic soils and podzols *sensu stricto* seems more satisfactory for use in Upland Britain than the single division made in the US classification, identification of borderline profiles presents difficulties in both systems, and replacement of the brown earth/brown podzolic separation by one placing primary emphasis on contents of amorphous aluminous material merits consideration.
6. The soils grouped as ironpan and ferric stagnopodzols have also been classified differently in the US taxonomy and other systems. As these soils appear to have originated by similar processes and have properties important for plant growth in common, grouping them into different classes at the highest categorical level seems inadvisable. Whether they should be grouped with podzols *sensu stricto* or gley soils is debatable, but chemical properties suggest that the former affiliation is preferable. (Avery and Clayden, with Mr. J. M. Ragg, Soil Survey of Scotland).

Attention has been focused on ways of differentiating a limited number of series within subgroups of the new system, with the aim of constructing individual keys for subgroups rather than guidelines for universal application. Principles to be used for different classes of soil are being tested by application to various soil groups. (Clayden, Avery, Carroll and Robson)

Several profiles were sampled to assist in separation of humic gley soils (*sensu stricto*) from stagnohumic gley soils. (Clayden and Wright, with P. Ashworth, vacation worker)

Systematic symbols and related acronymic codes to name profile classes were developed to be applied to field classification and map making. Taxon and Tolerance classes are defined, the latter giving controlled flexibility leading to rationalisation of concepts such as similar soils, variants, taxadjuncts, non-limiting inclusions and borderline polypedons and so to efficient summary, transfer and storage of soils data. (Green)

Automated cartography

Work continued on the mapping of data from the survey of the Ivybridge district (Sheet SX 65) in Devon using the GRID CAMAP program of the Edinburgh Regional Computing Centre (ERCC). However, transfer of the batch processing machine (IBM 370/158) and special line printer from Edinburgh to Newcastle late last year slowed progress considerably. It now takes a week to ten days to obtain output after submitting a job, and further work has been postponed until the programs can be used on the new equipment being or to be installed at Edinburgh. (Webster)

Multivariate analysis

Earlier work on the application of multivariate methods in the reconnaissance stage of soil survey has been completed. In collaboration with P. A. Burrough, formerly of the Land Resources Division of the Ministry of Overseas Development, a reconnaissance soil classification for Sabah was improved using multiple discriminant analysis. The value

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of canonical correlation analysis for relating soil to its environment and for predicting soil at unseen sites from a knowledge of their environment was assessed using survey data from Britain and Australia. The technique revealed relationships that had not been identified previously, but predictions were subject to too large errors for them to be of great value. (Webster)

Data management

DECODE, the computer program written in collaboration with Mrs. C. M. Lessells of the Computer Department, is now being used regularly by surveyors. A program for handling records from the Survey's Rothamsted laboratory is being written, and the program for handling raw laboratory measurements of soil moisture retention, density, stoniness and particle size has been modified so that results can be stored in the computer.

The problems of storing, searching, retrieving and collating large bodies of soil data are being studied in collaboration with Oxford University. The G–EXEC system written by Mr. K. G. Jeffery and Mr. E. M. Gill of the Natural Environment Research Council (NERC) seems especially suitable for handling soil data. It is being implemented on the Rothamsted machine by Mrs. C. M. Lessells and when working will be used in this study. (Webster)

The program processing water retention data has been amended to include stone content and packing density and there will soon be a store of results for use by Soil Survey staff in conjunction with that of soil profile descriptions. (Hall and Mrs. Wright)

The punched feature card system at the Lincoln office which now holds details of 762 published soil series, supplied information to surveyors and external users on 38 occasions. (Heaven and Robson)

Remote sensing

Cambridgeshire Fenland. About 7 km of cleaned ditch section was examined to the north of Whittlesey. The ditch runs north-east parallel to the course of the Nene from TL 276995 to TF 346015. The depositional sequence is similar to that seen elsewhere in the southern Fens, of Upper Peat/Fen Clay/Lower Peat. The Fen Clay can usually be subdivided into a browner, more silty horizon over the greyer, clayey deposits more characteristic of the Fen Clay to the south. This upper horizon is thinner and of coarser particle-size class in the east. Small, infilled former estuarine marsh creeks are often found in the upper layer of the Fen Clay, but the larger creeks, of very fine sandy loam particle-size class, often cut into and through the Fen Clay. The Upper Peat, often between 50–100 cm deep, is thinner over creeks and thins to the east, topsoils being humose rather than peaty. In parts of the section the Lower Peat is within 1·5 to 3 m of the surface but elsewhere it was deeper than 3–4 m and was not visible in the bottom of the ditch. At one locality, on an 'island' of disturbed Jurassic clay with gravelly and coarse silty drift deposits, the Lower Peat comes to within 0·75–1 m of the surface.

On air photos the tonal pattern of light-toned creeks and darker toned inter-creek areas are similar to those seen on photos of the southern Fens, but tonal contrast is slightly less. The density of creeks is less in the southern Fen. (Evans)

Air photo interpretation. An air photo interpretation soil map was made of the Humberside Region from good quality 1:60 000 scale air photos taken by the RAF. The photos of the Vales of York and Pickering, and of the Yorkshire Wolds were taken when the ground was bare of crop and were extremely useful. (Evans)

Crop patterns. As in 1975 the growth and yield of wheat was monitored at Maxey, Cambridgeshire in relation to air photographs taken during the year. Yields in the very

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dry summer of 1976 were less than in 1975 and again were related to soil depth, being larger where loamy and clayey soils of the Maxey series are thick over gravel.

Growth and yield of cereals was also recorded on: (1) a periglacial stripe pattern in chalk soils; (2) a valley floor pattern on chalky boulder clay soils; and (3) on a lithological pattern on soils on limestones and clays. On the stripe pattern yields were very small but best on the shallowest soils over chalk (Newmarket series), not on the deeper sandy loam soils (Swaffham Prior series). Germination and early growth were best on the deeper, darker coloured soils but as the season progressed growth on these soils was retarded whereas it continued unchecked on the shallower soils. On the Chalky Boulder Clay soils yields were greatest in the drift-filled valley floor where soils are less calcareous, deeper to the impenetrable C horizon, and which wetted up to a greater depth in the 1975/76 winter. Germination and growth were poor on the adjacent eroded Hanslope soils of the spurs and valley sides.

The differences in growth of cereals on a soil pattern (Sherborne/Ufford/Denchworth/Evesham/Sherborne) in Leicestershire, clearly seen on air photos taken in July 1971, were not easily observed in the summer of 1976, except on soils with limestone at less than about 0·3 m. The pattern is not seen when soils are bare of crop.

Previous work has shown that cereal yield is related to depth of soil, and that, in a given field, the height of the crop at ripening of the ear is a reasonable indicator of yield. Taller crops have a greater leaf area and show as darker tones on air photos. Further work is in progress on Sheet TF 00E/10W (Barnack) where air photos were obtained on 1 July 1976, covering about 60 km^2, and the heights of cereals were subsequently measured on known soils and await comparison with the photo tones. (Evans)

Soil mapping

In Pembrokeshire the selected 1:25 000 maps have been related to the County map drawn from aerial photographs and geological and topographical data. Soil information from grid profiles and nested sampling sites was used to assess the contents of map units. Sheet SN 13 (Eglwyswrw) was used for detailed comparisons. The land unit mapping compares well with the ground survey (with some 80 auger borings per km^2); both maps predicted soil series correctly at about 70% of grid points. (Rudeforth)

Applications research

Winter rain acceptance potential

A *Technical Monograph* has been written jointly with staff of the Institute of Hydrology (NERC); four chapters describe the hydrological background to run-off assessment, characterisation of soils in five hydrological classes, the construction of a national winter rain acceptance map, and the use of this map in hydrology. (Mackney and Thomasson, with Messrs Farquharson and Newson of the Institute of Hydrology)

Land use capability map

A land capability map of England and Wales at 1:1 000 000 is under construction. It shows the distribution of dominant and subdominant classes and subclasses, derived from slope and climate overlays on the soil map. The extended legend describes the management characteristics and land use of map units and incorporates relevant climatic data. Drafts of legend and map have been widely circulated among ADAS staff for comment. (Mackney)

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Exposure

A provisional map of wind exposure in England and Wales was prepared at a scale of 1:1 000 000. The distribution of varying oceanic influences in the climate of England and Wales is being established. (Hartnup with Mr. E. L. Birse, Macaulay Institute for Soil Research)

Soil suitability for direct drilling

At the suggestion of a joint ARC/ADAS working group, a national survey was started to extend practical experience of direct drilling to a wider range of soils and situations. In all, 65 fields were visited, the soils described and mapped, and packing density measured at most sites. The data will be studied in relation to comprehensive farm records acquired by ADAS for the same sites, with the aim of constructing a soil suitability classification for direct drilling. Many experimental direct drilling sites have also been visited and the soils classified and mapped. (Soil Survey Staff)

Demonstration farms project: Countryside Commission

The survey has supplied soil information for farms chosen to participate in this project to demonstrate that landscape conservation and improvement can be effectively combined with profitable farming. (Soil Survey Staff)

Supporting work

Particle-size and chemical analyses

Approximately 1800 samples from 350 profiles sampled in current mapping and research projects were analysed in the Headquarters laboratory using methods given in the *Soil Survey Technical Monograph on Laboratory Methods* (25). (Bascomb and Thanigasalam)

Samples from approximately 30 profiles from the Nuneaton district were analysed in the Wellesbourne laboratory. (Beard)

Mineralogical analyses

The composition of 166 clay ($<2\ \mu m$) separates was investigated using X-ray diffraction, non-exchangeable potassium and cation-exchange capacity measurements (25). Most samples were from clayey soils identified in current mapping projects, particularly Sheet SP 29 & 39 (Nuneaton): others were analysed in connection with basic research on stagnogley soils and the work of the Rothamsted Soil Structure Working Group. (Bullock, Loveland and Mrs. P. C. Murphy)

Another 60 samples were obtained and prepared for analysis this winter, including soils from the Longtown district and from the Newport and Clifton series in Cumbria, Cheshire and the Midlands. (Kilgour)

Micromorphology

Five hundred and seventy thin sections were made from samples collected in current mapping projects, and described to aid soil characterisation and classification in the areas concerned. A further 160 large sections were made for research projects, particularly micromorphometry. (Bullock, C. P. Murphy and Biswell)

Soil Survey and Drainage Service (ADAS) Joint Project

A project to monitor soil water regimes by the dip-well method in drained and undrained fields on major soil series is now established, and Staff in all regions have helped to choose

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suitable sites. During the winter of 1974–75, 226 sites were visited weekly by staff of the Drainage Service to record water-table depth. The sites were distributed among the Advisory Regions as follows:

Eastern	22 sites
East Midlands	20 sites
West Midlands	33 sites
South East	18 sites
South West	42 sites
Wales	44 sites
Lancs, Yorks	31 sites
Northern	16 sites

The number of soils and fields monitored is expected to increase in 1976. Initial analyses have been made by FDEU and Survey staff. (Mackney, Thomasson and regional staff)

Soil water regimes

In the spring, water regime studies using the neutron probe were begun on two sites near Sleaford (Deepdale and Denchworth series) and three sites near Draycott-in-the-Clay (Salop, Newport and Worcester series). Unfortunately the Denchworth soil cracked considerably vitiating the results and the Deepdale site was lost through ploughing. The sites were abandoned in October, but the sites in Staffordshire, all under grass, will be visited for at least another season.

From neutron probe measurements, it is possible to compare actual soil moisture deficits with estimates obtained from climatic data and to measure the period for which soils are at or above field capacity. The results from the Lincolnshire sites, monitored from spring 1974 to spring 1976, are now being analysed. (Hall, George, Heaven and Jones)

A project to compare the water content distribution of Wick soils under grassland and arable has been started at the National Vegetable Research Station, Wellesbourne. Six neutron probe access tubes have been installed in a small plot and the water regime will be monitored for two years. (Whitfield)

Water levels were again recorded at 12 sites on glaciofluvial sand at Skipwith Common, to establish present water regimes before the land is affected by the projected Selby coalfield. (Furness and S. J. King)

Soil water retention properties

Water retention properties were determined for a total of 681 core samples from 65 profiles. This number, more than last year, was achieved by omitting measurements at 2 bar suction to clear the backlog of samples. For a few profiles water contents were determined at only 0·05 and 15 bar suctions, which will continue until the new enlarged laboratory facilities are built at Shardlow. (Hall and Mrs. Wright)

Water-release characteristics were determined for 70 core samples from 16 profiles representing some of the main soils of the Nuneaton district. (Beard)

Special surveys

A rapid reconnaissance survey of 1200 km² of upland Northumberland, from the river Breamish to Allendale, was made at the request of ADAS staff concerned with the Northumberland Hill Farming Project. Air photos were used extensively, particularly to delimit steep slopes, areas of deep peat and other soils of limited agricultural potential. A generalised soil map and brief explanatory report were prepared. Data collected during

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the survey will be used in future, more detailed soil surveys. (Carroll, Bendelow and Kilgour)

At the request of the Cheshire County Education Department a brief survey was made of Delamere Forest and several monoliths representing typical soils were prepared for the Delamere Forest Outdoor Education Centre. (Furness and S. J. King)

A low, semi-circular ridge near Thorney, Cambridgeshire, seen from aerial photographs is thought to be the remains of the large hydrolaccolith (pingo) formed in thin terrace deposits over Oxford Clay in a periglacial environment. During the summer it was levelled and the deposits were mapped. Its central depression measures 830 by 1300 m and is filled with calcareous alluvium. The encircling ridge is mainly sandy, and there is a 200 m wide sandy aureole within it. A gap occurs in the rampart and it is thought that through this meltwaters escaped and the sea later gained access *via* a rodham supplying much of the alluvial infill. (Burton, with T. Barker, student worker)

Under a contract with the Boots Company Ltd (Nottingham) a grid survey of 50 ha of land at Thurgarton was made to identify uniform plots of land suitable for the testing of new agricultural chemicals. (Hall and Thomasson)

A survey of the Warwickshire College of Agriculture, Moreton Morell, was made at the request of the Lands Arm of ADAS. This was used as a basis for a field excursion by Lands Arm officers to discuss the division of Grade 3 land in their Agricultural Land Classification. Nine monoliths representing the soils of the farm were prepared for exhibition at the Royal Show at Stoneleigh. (Whitfield and Beard)

A soil survey of Bagots Park Estate, 325 ha, was made for an ADAS Staffordshire farm demonstration. A hand-coloured soil map at a scale of 1:10 000 was prepared from the field sheets and a report described the soils and their relationship with agriculture. The estate forms part of the 1:25 000 Sheet SK02 (Abbot's Bromley) now being surveyed. (Jones)

A detailed survey was made of the Teifi Marsh Nature Reserve, West Wales Naturalists Trust (125 ha). Soils were described over Lower Palaeozoic sediments, and in Irish Sea clay and alluvium. (Bradley)

A soil map is being completed of land farmed by the Llysfasi College of Agriculture in the Vale of Clwyd as a teaching aid to familiarise students with soil maps and the identification of soil types. (Lea)

At the request of ADAS, the survey of SJ 17 (Holywell) was extended by about 3 km^2 to include the whole of Halkyn Mountain, to study heavy metal contamination. (Thompson)

Other work

The Rothamsted Soil Structure Working Group of staff of the Chemistry, Pedology, Physics and Soil Microbiology departments, and the Soil Survey are studying the structure, porosity, stability and shrink-swell properties of six profiles of commonly occurring soil series—Hanslope, Ragdale, Denchworth, Evesham, Salop and Flint. The techniques include optical methods (Quantimet), mercury intrusion and ultra-sonic dispersion, as well as particle-size and chemical analyses, and water retention measurements. It is hoped to hold a seminar in 1977 presenting the results, before publication. (Bullock and Thomasson)

The Survey was represented on an ADAS Working Party studying problems associated with copper deficiency in cattle in North Yorkshire. A soil map showing soils with a probable large molybdenum content was prepared and related to geochemical data provided by Imperial College, London. Investigation of sample farms suggested, however, that total sulphur content has most effect on copper availability and that molybdenum has a secondary effect, also sulphur-dependent. (Carroll)

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Help has been given to the Soil Science Department of Aberdeen University in their studies of the effects of different tree species on physical properties and nutrient status of soils of the Bromsgrove series at Weston Park Estate, Shifnal, Salop. (Jones and Hodgson)

In collaboration with Dr. C. J. Argent of the Gas Council's Experimental Research Station, the corrosion potential of a wide range of drift soils in Lancashire was determined to assess the usefulness of soil maps in areas of drift. The results were encouraging and indicated that corrosion potential varies significantly according to the soil material and that soil maps are useful for predicting areas of high corrosion risk, when planning pipe-line routes. (Furness)

The development of guidelines for the interpretation of soil maps over a wide range of land uses was commenced. The method is to search relevant literature, consult experts and evaluate available experimental data. So far, land use for agricultural engineering, farm-based recreation and specific cropping have been studied and draft guidelines prepared. (M. G. Jarvis)

A study was made of the limitations of soil for use as footpaths in Lincolnshire and the Peak District. (George)

The opportunity presented by arterial drainage works has again been used to record Fenland stratigraphy. North of Warboys, Cambridgeshire, a very large rodham marks the pre-Bronze Age course of the Ouse. Beneath is a deep wide channel filled with peat (the Lower Peat) comparable to similar channels seen beneath the Ely Ouse and the Little Ouse. Nearby, the junction between Lower Peat and the Fen Clay is irregular. (Seale)

An exhibit illustrating the work of the Survey was prepared for a 'Town and Country Day', attended by approximately 10 000 people, at the Bishop Burton College of Agriculture on 27 June. (Furness and S. J. King)

An exhibit of publications and monoliths describing the work of the Soil Survey in the south-west was arranged and demonstrated at Long Ashton Research Station's Open Day. (Cope)

An exhibit on the work of the Soil Survey was prepared for a symposium on the Burry Inlet held at University College, Swansea. (Wright)

Field excursions were organised for the North of England Soils Discussion Group, the Quaternary Research Association, Sheffield University, and the Welsh Soils Discussion Group. Advice and assistance was given to many organisations including:

1. ADAS Officers in all regions.
2. ADAS Lands Arm.
3. ADAS Drainage and Water Supplies Division.
4. Broom's Barn Experimental Station.
5. Letcombe Laboratory.
6. Grassland Research Institute.
7. Institute of Hydrology.
8. Forestry Commission.
9. Welsh Office.
10. Clwyd, Dyfed and West Glamorgan County Councils.
11. DOE—North Yorkshire County Council Working Party.
12. Atomic Energy Research Establishment.
13. Welsh National Water Development Authority.
14. South West Wales River Division.
15. Economic Forestry Group (Wales) Ltd.
16. Southern Gas Board.
17. Essex Naturalists Trust.

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18. Oxfordshire Rural Environment Studies Association.
19. Rycotewood College.
20. Oxfordshire County Museum.
21. Passmore Edwards Museum.
22. Billericay Archaeological and Historical Society.
23. Chelmsford Archaeological Excavation Committee.
24. Dyfed Archaeological Trust.
25. Essex, Humberside and Oxfordshire Archaeological Units.
26. Exeter University Archaeology Department.

Publications

During the year, 11 soil maps and land use capability (LUC) maps were published in outline editions as part of the standard 1:25 000 series. A further 16 soil maps and 10 LUC maps at this scale are in preparation, including the first coloured sheets of the series. Sheet TR 04 (Ashford) has been reprinted.

At 1:63 360 scale, 7th Series Sheet 135 (Cambridge and Ely) has now been printed in outline edition. Other miscellaneous scale maps are in course of production including 3 county soil maps at 1:250 000 scale (South and West Yorkshire, Cheshire and Norfolk) and a Winter Rain Acceptance Potential map of England and Wales at 1:1 000 000 scale. It is intended that these maps will be published in colour.

In spite of delays caused by building alterations to the photographic darkroom, over 700 miscellaneous diagrams and prints were produced for publication and display.

The *Generalised Soil Map of England and Wales* and a selection of other maps were shown at the 23rd International Geographical Congress and the 8th International Cartographic Association Conference, in Moscow and in Budapest, for an exhibition entitled 'Maps in the Service of Agriculture'. (Thomson)

Nine *Records*, the penultimate *Memoir* and one *Special Survey* were published. One *Memoir*, 12 *Records*, 4 *Technical Monographs* and 2 *County Bulletins* are being published. The *Field Handbook* and *the Land Use Capability Technical Monograph* are being reprinted.

Staff

K. E. Clare attended the 'Seventh International Conference on Soil Tillage' at Uppsala, Sweden, in June, and visited the Swedish Royal College of Forestry.

R. A. Jarvis visited Murcia, Spain, for three weeks to advise on a UNESCO post-graduate course, 'Natural Resources Research and Land Evaluation', organised by the University of Sheffield.

S. J. King visited the Netherlands for three weeks at the request of the National Farmers' Union to study reclaimed soils and the part played by soil survey in the planning and execution of reclamation and in the subsequent agricultural development of such areas.

Dr. J. L. Guardiola Saenz (Zaidin Experimental Station, Granada, Spain) made the second of two three-month working visits to Harrogate under the European Science Exchange Programme.

P. Bullock attended meetings of the International Working Group on Soil Micromorphology in France and chaired a session on the micromorphology of soil organic matter. He also accepted an invitation from the University of Gent, Belgium to lecture on soil micromorphology to its International Training Centre in December.

C. C. Rudeforth visited the Macaulay Institute for Soil Research to see work of the Soil and Peatland Surveys of Scotland.

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The Survey has been awarded a 3 year Science Research Council CASE studentship jointly with Oxford County Council to study the utility of soil surveys in engineering and land planning. N.E.G. Johnson has been appointed, and works at the Weed Research Organisation, Oxfordshire.

W. A. D. Whitfield judged the Warwickshire County heats of the Young Farmers' Club National Soil Assessment and Management Competition at Moreton Morrell.

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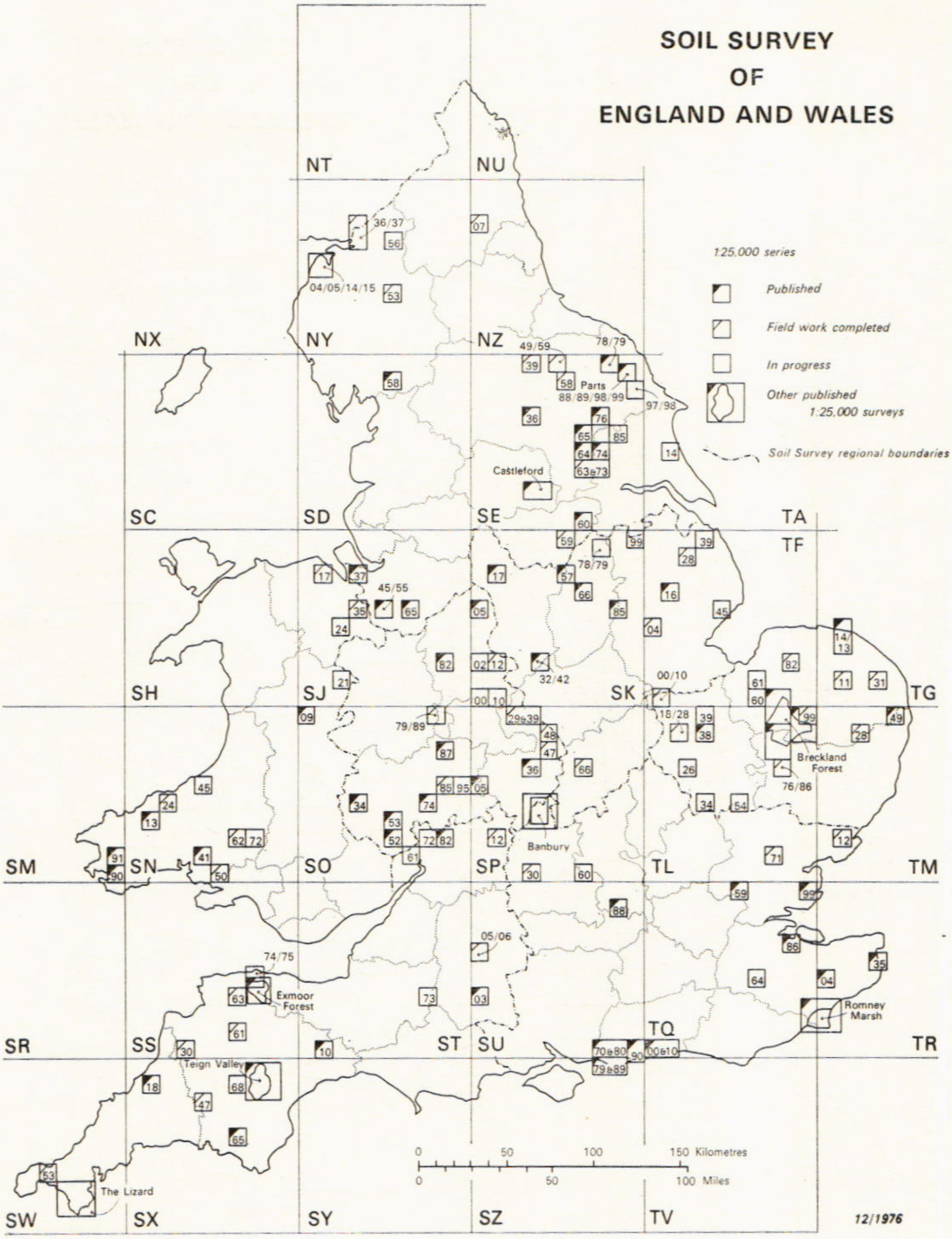

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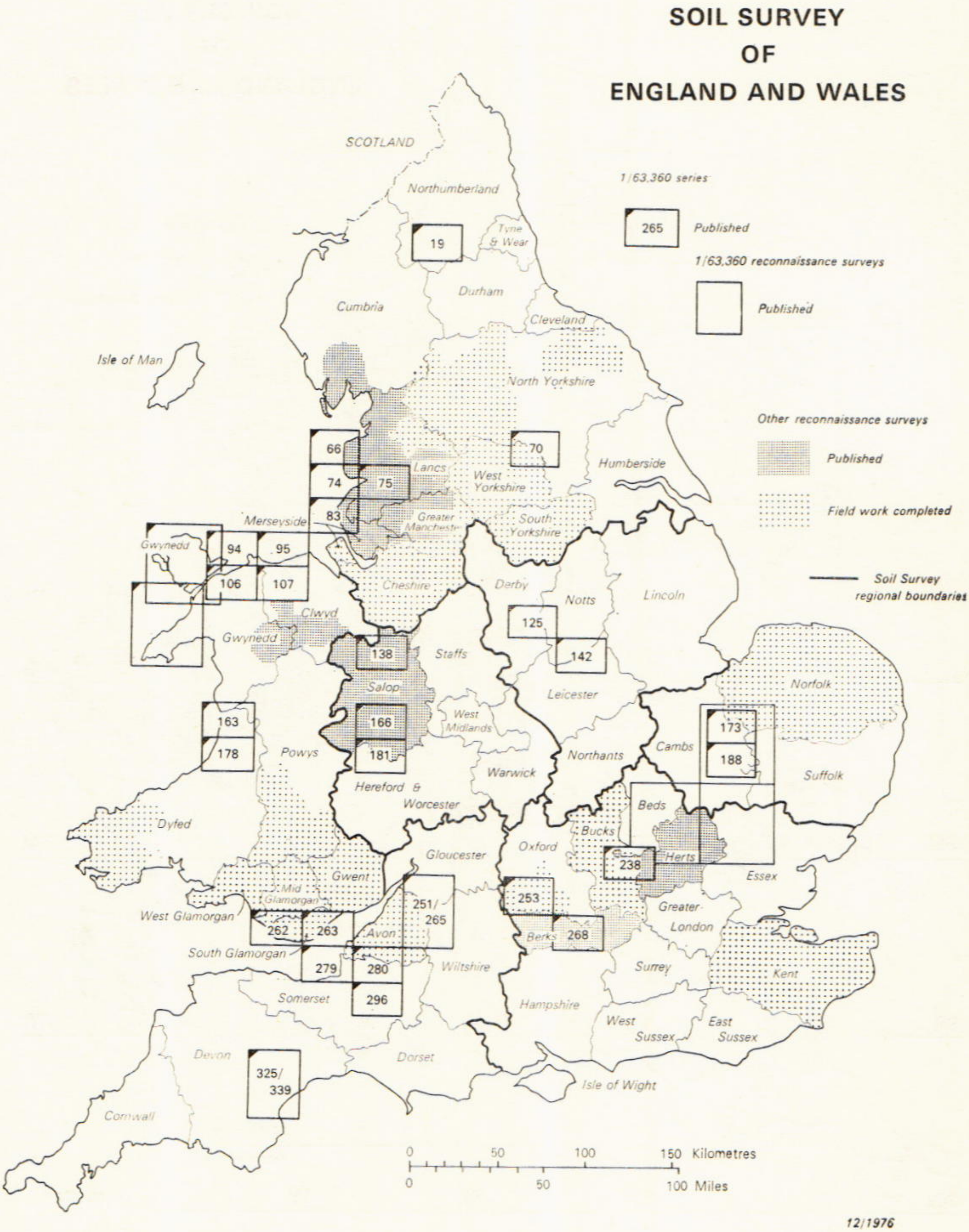

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SOIL SURVEY OF ENGLAND AND WALES

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