SOILS OF SHROPSHIRE

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Soil Survey of England and Wales

CONTENTS

INTRODUCTION

THE first modern account of the soils of Shropshire was written in 1912 by G. W. Robinson who adopted a soil classification based on geology. In 1926, a soil survey of north Shropshire was started at Harper Adams College, and the results of detailed mapping were reported by Davies and Owen (1934). The Soil Survey memoir and map of the Wem district (Crompton and Osmond, 1954) included work by Davies and his colleagues, and in the same year a survey was started in south Shropshire which resulted in the publication of a soil map of the district around Church Stretton (Mackney and Burnham, 1964). The 600 square miles of the county mapped in detail include unpublished surveys in south and south-western Shropshire. The appended map at the scale of $\frac{1}{4}$ inch to 1 mile was compiled from these surveys, from an interpretation of geological drift maps and from other information.

Emphasis is placed in this paper on the relationships between semi-natural vegetation and soils. A broader discussion of the agricultural properties of soil classes is contained in *Soils of the West Midlands* (Mackney and Burnham, in the press).

I. SOIL PROPERTIES

The soil profile is the unit of study in pedology and soil survey. It consists of the various layers or soil horizons, including relatively unaltered geological material (usually the parent material), to be seen in vertical sections, cuttings and pits. The recognition and description of the properties of soil horizons require a specialized technique for which a scheme is offered in the Soil Survey Field Handbook (1960). Munsell Soil Color Charts are used to record soil colours; in this system the soil is compared with a series of standard colours designated by a number and letter notation (e.g. 10YR 5/4) as well as a description in words (e.g. yellowish brown). Soil texture and structure are important properties affecting the physical constitution of soils.

(1) *Soil texture*

Soil particles less than 2 mm. in diameter are grouped in three size grades, i.e. sand (2-0·05 mm.), silt (0·05-0·002 mm.) and clay (smaller than 0·002 mm.). The various classes of soil texture are determined by the proportion of these size grades present in a sample. Particles greater than 2 mm. diameter are described separately, e.g. as gravel, stones, etc. Soils in which sand and clay are the principal constituents fall into five classes in order of increasing clay content: sand, loamy sand, sandy loam, sandy clay loam, sandy clay and clay. Similarly, soils composed mainly of silt and clay may be classed as silt, silt loam, silty clay loam, silty clay or clay; loam and clay loam include appreciable amounts of all three size grades. Sands and loamy sands are coarse-textured, and are regarded as "light" because they work easily, but their water retentivity is small. Soils of medium texture (sandy loam and loam) are excellent for most agricultural purposes, silt and silt loam textures are less so because their tilth is easily destroyed. Clay loam and clay soils are fine-textured, heavy working and unduly retentive of moisture. A rough estimate of texture class can be made by working moist soil between the thumb and fingers.

(2) *Soil structure*

Structure describes the shape and size of aggregates (peds) of soil particles; the aggregates are often small near the surface (crumb or fine blocky) but are larger in fine-textured subsoils, where they may be equidimensional (coarse blocky) or vertically elongated (prismatic). Structure is produced by the natural processes of wetting and drying, freezing and thawing, and by the activities of roots and soil fauna, and is not exactly the same as tilth, which is produced by cultivation and fragmentation of peds.

II. Soil processes

Soil horizons result from the interactions between a relatively few complex and imperfectly understood processes and the soil parent material.

(1) *The incorporation of organic matter*

The uppermost horizons of a soil profile are generally darker in colour and richer in organic matter than lower horizons, because plant remains falling on the surface are transformed and mixed with mineral soil over a limited depth by soil organisms. The rate plant remains decompose depends on environmental conditions; in base-rich well-aerated soils it is usually swift, and mineral and organic components are thoroughly mixed to form mull; in strongly acid soils the rate of decomposition appears to be slower, and the organic horizons, more or less clearly separable from the mineral soil, are termed either moder or mor (q.v., p. 89); peat is characteristic of more or less permanently waterlogged sites where decomposition is slow.

(2) *Leaching, mechanical eluviation and podzolization*

In Britain part of the rain arriving at the soil surface is evaporated or, after penetrating a short distance, is taken up and transpired by plants, and part may

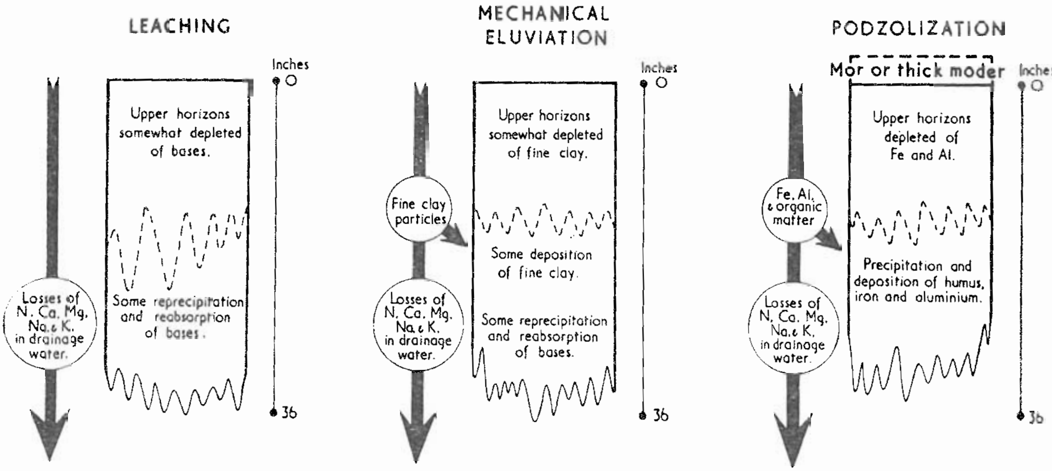


FIG. 1.
Processes connected with the movement of soil water.

run off the surface. The remainder soaks through the soil, and may cause leaching, mechanical eluviation and podzolization (Fig. 1).

Water moving through the soil dissolves and removes soluble components—the process of leaching. The upper soil horizons are, therefore, continually being depleted of bases, such as calcium, magnesium, sodium and potassium, and unless the losses are made good by additions of lime and fertilizers soils tend to become impoverished and acid.

Fine soil particles, such as clay, may also be moved downwards whilst suspended in soil water, and when subsequently deposited form a layer containing more fine particles than layers above or below. Clay transported in this way is usually unchanged in composition, and the process is known as mechanical eluviation.

Podzolization is associated with strongly acid moder or mor; organic compounds liberated by decomposition of plant residues react with iron oxides to form complexes that readily move in percolating solutions, so forming a well-defined, bleached, subsurface layer depleted of iron, below which lie contrasting dark-coloured and ochreous layers where humus and hydrated oxides of iron and aluminium respectively have been precipitated.

(3) *Gleying*

Soils periodically or permanently waterlogged develop horizons variegated or mottled with grey and ochreous colours; these are caused either by reduction and re-oxidation of iron compounds under alternating anaerobic and aerobic conditions, or by partial removal of iron in the more soluble ferrous form.

This process, known as gleying, largely reflects microbiological activity.

III. Factors of soil formation

Soil horizons result from the modification of parent material by soil processes. The extent of modification depends on the nature of parent material, on past and present environmental factors such as climate, vegetation and hydrologic conditions, and on the length of time the processes have been acting in more or less stable landscapes. Human influence in particular has greatly disturbed previous equilibria and caused major changes in vegetation and the characters of soil horizons.

(1) *Parent material*

The parent materials of soils in Shropshire are varied, and include igneous and metamorphic rocks, sedimentary rocks ranging from the pre-Cambrian to the Jurassic system, and extensive superficial deposits (Whittard, 1952). The last include sands and gravels, tills, lacustrine clays, alluvium and peat, which, particularly in the northern half of the county, mask the underlying rocks.

The physical and chemical properties of parent materials greatly influence the character of soils. Soil texture largely depends on the size distribution of minerals in the parent material, and texture further influences other soil properties such as structure, consistence and permeability.

The content of bases in soils profoundly affects soil formation. Quartzose sands are highly permeable, readily leached of their small amount of calcium and magnesium, and, under semi-natural conditions, give strongly acid soils. Edaphic factors favour an acid-tolerant vegetation and the formation of mor or moder which promote podzolization. In contrast, soils on parent materials rich in calcium and magnesium are associated with a basicole vegetation and an environment promoting vigorous decomposition and incorporation of organic residues, preventing podzolization.

(2) *Climate*

The elements of climate mainly affecting soil development are rainfall and temperature, and, although often considered separately, they do not operate independently. In Shropshire climate obviously depends on altitude, and the uplands are colder and wetter than the lowlands. These differences are accentuated when account is taken of the amount of water lost by evapo-transpiration.

	Longmynd (1,696 ft.)	*Shrewsbury* (200 ft.)
Rainfall	40 in.	23 in.
Evapo-transpiration	19 in.	19 in.
Maximum available for soil formation	21 in.	4 in.

The value of 19 inches for Shrewsbury is taken from Penman (1950); a value of 19 inches is assumed for the Longmynd, which is probably too large when lower temperatures, greater cloudiness and relative humidity are taken into account. Thus where run-off is not considerable, much more water percolates through the soil in upland than in lowland areas with the following effects:

(i) Leaching is more intense in the uplands, and soils are mostly strongly acid and impoverished, supporting a moorland or heathland vegetation.

(ii) Podzolization is widespread in the uplands, and not confined to very coarse-textured materials as in the lowlands.
(iii) Soils are waterlogged for long periods in the uplands, and gleyed soils are prevalent.
(iv) Cold coupled with wetness are conducive to the accumulation of organic debris at the surface, occasionally forming hill peat.

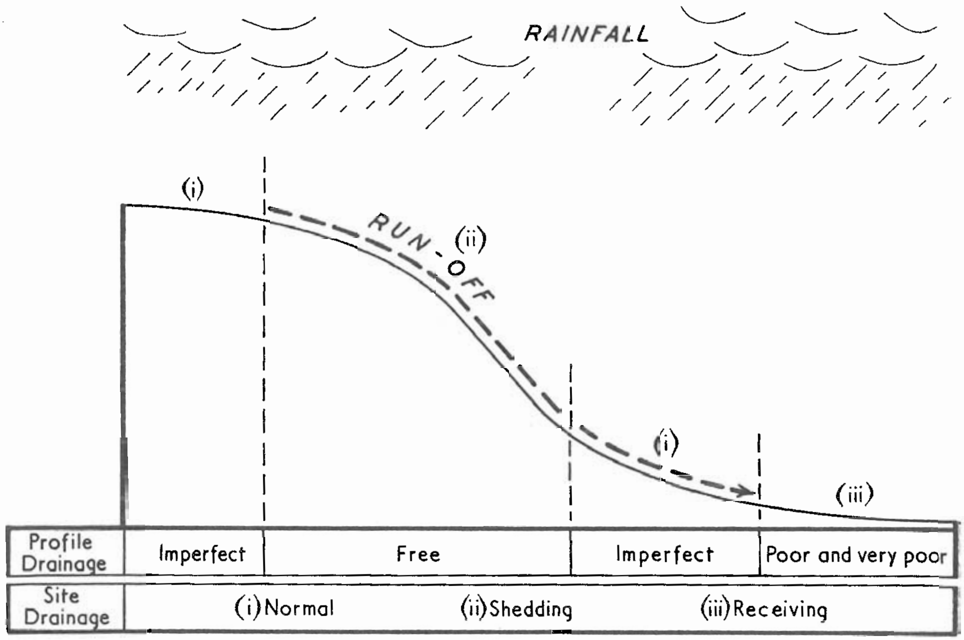


FIG. 2a.
Hydrologic conditions on sloping sites underlain by relatively impervious strata.

(3) *Relief*

In addition to changes of climate associated with relief, the most important indirect effect of relief on soil formation is its influence on hydrologic conditions. On rolling land underlain by relatively impervious medium- or fine-textured substrata, rain that does not penetrate the soil or is not transpired by plants runs off the surface or accumulates in depressions, leading to different hydrologic conditions (Fig. 2a). Where the substrata are pervious, direct run-off is less important, but water moves underground, often re-appearing as springs (Fig. 2b).

The drainage of soils is broadly related to relief and thus poorly-drained and very poorly-drained soils occur in flat sites, some of which receive run-off water, well-drained soils are found in shedding sites, and imperfectly-drained soils in intermediate positions.

(4) *Vegetation*

Plant communities partly determine the nature of organic horizons which in turn influence processes such as podzolization and leaching. The form and extent of rooting systems affect soil structure, the rate water is removed from soil and the re-cycling of plant nutrients. The amount and kind of vegetation influences the microclimate and the liability to erosion.

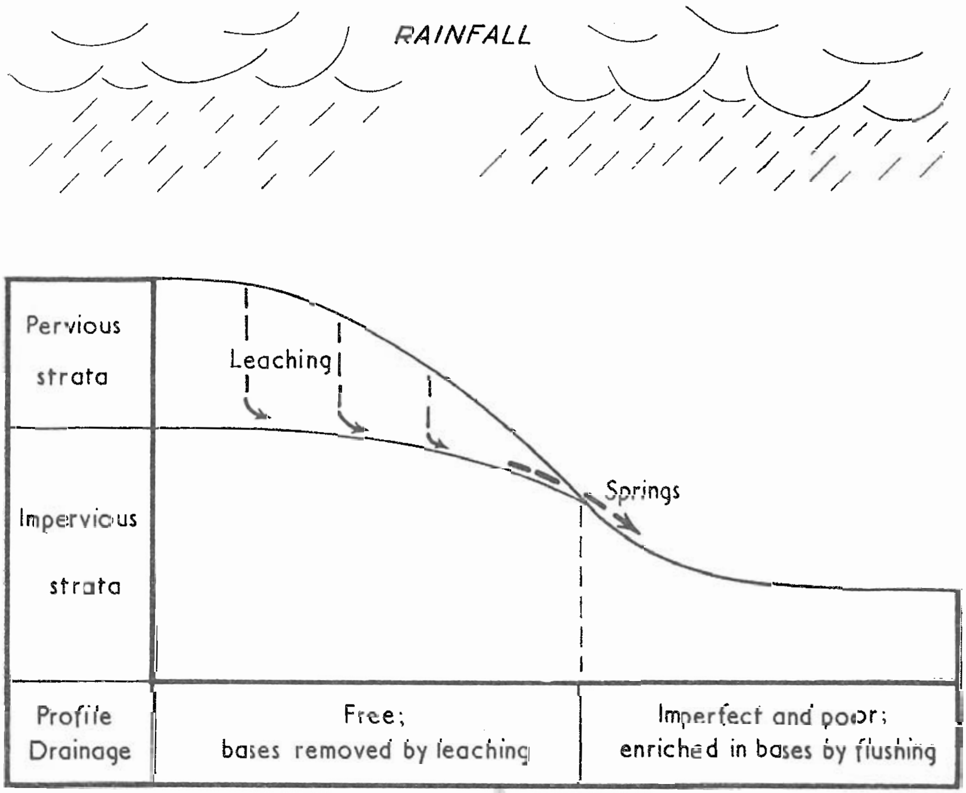


FIG. 2b.

Hydrologic conditions on sloping sites with pervious and impervious strata.

(5) *Animals*

The activities of the soil population are closely linked with the vegetation, and in turn profoundly influence the soil. The assemblage of soil organisms, both large (Kühnelt, 1961) and small (Burges, 1958), depends on the type of plant community, which itself depends on the hydrologic conditions and base status of the soil; the organisms break down plant debris, releasing nutrients and other compounds concerned in soil-forming processes.

(6) *Human activity*

Man has influenced the soil indirectly by modifying or replacing the native vegetation, and more directly and drastically by cultural practices including ploughing, drainage and the use of fertilizers and lime. Deforestation and grazing by animals have extended grassland and heath, and greatly changed the surface horizons and the moisture regime of soils.

IV. Classification of soils

No two soil profiles are exactly alike, so classification involves grouping together a defined range of similar soils. Schemes of classification for British soils appear in Clarke (1957) and Avery (1956). A classification into major soil groups and sub-groups suitable for Shropshire soils is set out below (Table 1); this incorporates many of the ideas of earlier systems, particularly those of Kubiena (1953) and Duchaufour (1960). It is based on the morphological and chemical properties of selected profiles from sites bearing semi-natural vegetation. Agricultural soils are less convenient for such studies, for differences are minimized by ploughing, liming and fertilizing, but, by making allowances for their effect, such soils can be placed in the classification.

Soil Horizon Notation

Organic surface horizons:

L Plant litter, only slightly comminuted.
F Comminuted litter.
H Well decomposed humus with little mineral matter.

Organo-mineral surface horizons:

A Dark brown, mainly mineral layer with humus admixture.
Ap Ploughed layer.

Eluvial horizons that have lost clay and/or iron and aluminium:

Ea Bleached or pale horizon which has lost iron and/or aluminium.
Eb Relatively pale brown friable horizon which has lost some clay.

Illuvial horizons enriched in clay or humus or iron and aluminium:

Bt Horizon enriched in clay.
Bh Dark brown or black horizon, enriched in humus.
Bfe Orange or red-brown horizon, enriched in iron and/or aluminium.

Other subsoil horizons:

(B) (pronounced "B bracket"). Weathered subsoil material, not appreciably enriched in clay, humus or iron, distinguished from overlying and underlying horizons by colour or structure or both.
C Little-altered parent material.

Notes:
g The addition of 'g' denotes mottling or greying thought to be caused by waterlogging.
ca The addition of 'ca' denotes the presence of secondary calcium carbonate.
A/(B), Bt/C, etc. Transitional horizons are indicated in this manner.

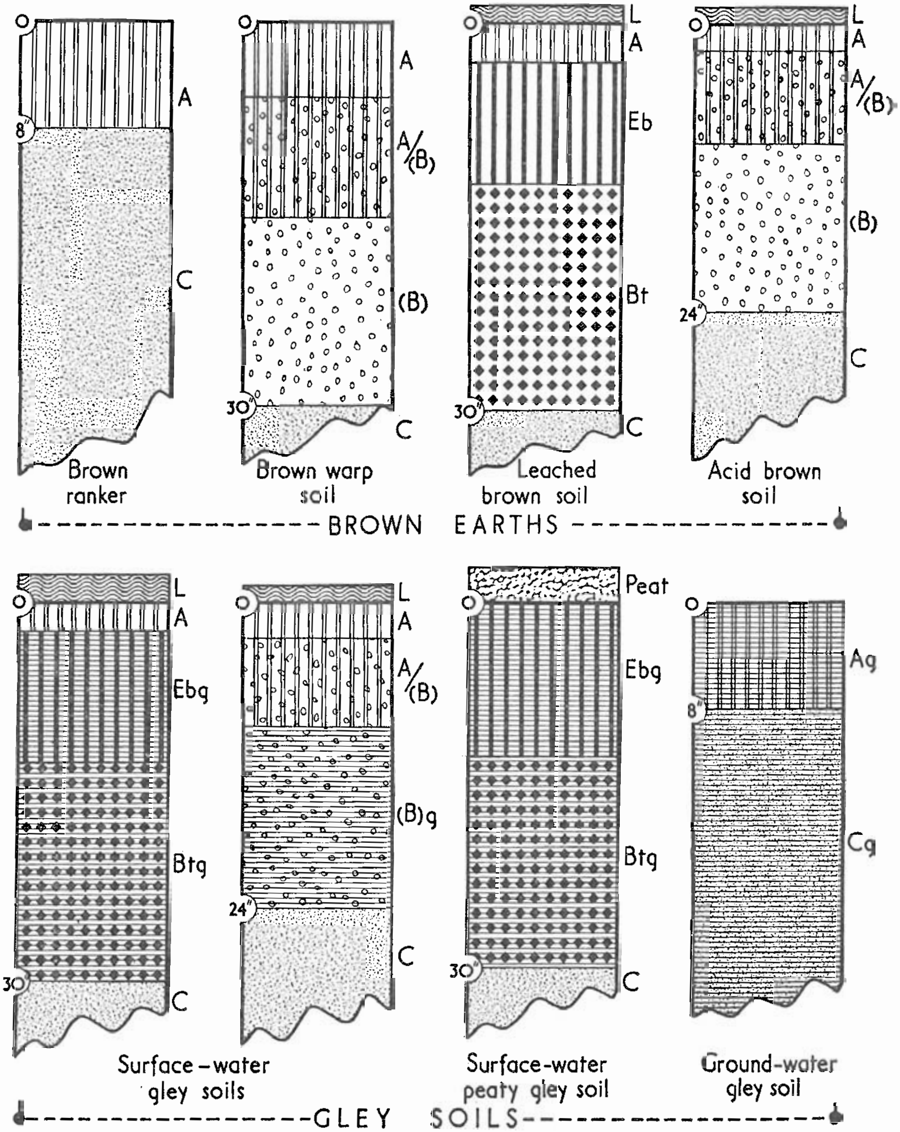
Mull is a characteristic A horizon, which may be covered by a thin L horizon, but F and H horizons are scanty or absent.
Moder characteristically has an H horizon thicker than the L and F combined.
Hydromorphic moder (Duchaufour, 1960) is a type of moder which is greasy, often plastic, partly formed in anaerobic conditions.
Mor (raw humus) has thick L and F layers.

Table 1. *Classification scheme*

Major group	*Sub-group*
Raw soils: very weakly developed soils with little or no humic material	Lithosols: slightly to strongly acid shallow soils on hard rocks or scree debris.
Calcareous soils: soils with $CaCO_3$ in all horizons or the A horizon is only slightly acid.	Rendzinas: shallow A, C soils with black or very dark brown calcareous mull overlying limestone.
	Brown calcareous soils: A, (B), C soils with calcareous or slightly acid mull; calcareous (B) horizon.
Brown earths: slightly to strongly acid soils with acid mull or moder.	Brown rankers: moderately to strongly acid A, C soils with mull over siliceous rocks, (B) horizon weakly developed or absent.
	Leached brown soils: A, Eb, Bt, C soils with acid mull or more rarely moder; moderately to strongly acid eluvial horizons. There are also leached brown soils with gleying.
	Acid brown soils: A, A/(B), (B), C soils with acid mull or moder; clay complex strongly unsaturated in all horizons. There are also acid brown soils with gleying.
	Brown warp soils: deep, slightly to moderately acid A, A/(B), (B), C soils with acid mull on alluvium. There are also brown warp soils with gleying.
Podzolized soils: strongly acid soils with moder or mor; distinct horizons due to illuviation of sesquioxides and organic matter.	Podzol rankers: Ea, C soils with mor or moder; bleached Ea horizon lying directly on rock or bouldery scree; Bh and/or Bfe horizons occur within rock crevices.
	Podzolized acid brown soils: A, Ea, Bfe, C soils with moder; pale yellowish brown or grey-brown Ea horizons; marked brown or orange-brown Bfe horizons.
	Podzols: Ea, Bh and/or Bfe, C soils; bleached Ea horizons; black Bh and/or brown or orange-brown Bfe horizons. They include humus-iron podzols and iron podzols.

Major group	*Sub-group*
	Peaty gleyed podzols: Eag, Bh/Bfe, Bfe, C or Eag, Bh/Bfe, (B), C soils with strongly acid thin peaty organic horizons; dark grey Eag horizons, dark brown Bh/Bfe horizons as thin ($\frac{1}{4}$ in.) hard pan; orange-brown Bfe, or brown (B) horizons.
	Gley podzols: Ea, Bh, Cg or Ea, Bh, Bfeg, Cg soils with moder, mor or thin peat; prominent bleached Ea and black Bh horizons, the latter frequently weakly cemented; lower horizons seasonally saturated with ground-water; Bfeg horizon often discontinuous or absent and Cg horizon is bleached.
Gley soils: soils with prominent characteristics resulting from waterlogging and reduction and re-oxidation of iron compounds.	Surface-water gley soils: slightly to strongly acid soils with acid mull or moder, either with greyish brown Ebg horizon with rusty mottles followed by Btg, C horizons, or with A, A/(B) or A/(B)g horizons succeeded by grey and orange blotched subsoil layers probably of (B)g or Cg character, only seasonally wet. There are also surface-water peaty gley soils.
	Ground-water gley soils: slightly to moderately acid soils with acid mull; grey Ag, Cg or A, A/(B)g, (B)g, Cg horizons, the lower part of the Cg horizon being more or less permanently waterlogged.
	Flush gleys: slightly to moderately acid Ag, Cg soils permanently waterlogged; no peaty horizon, though there may be several buried A horizons.
Organic soils: soils with at least 30 per cent organic matter in a surface horizon more than 15 in. thick.	Peat soils: slightly to strongly acid soils with more than 50 per cent organic matter in a surface layer more than 15 in. thick. These include fen peats and raised moss.
	Peaty soils: slightly to moderately acid soils with between 30 and 50 per cent organic matter in a surface layer more than 15 in. thick.

The sequence of horizons in most of the groups is diagrammatically indicated in Fig. 3.



O
8″
A
C
Brown ranker
O
A
A/(B)
(B)
30″
C
Brown warp soil
L
O
A
Eb
Bt
30″
C
Leached brown soil
L
O
A
A/(B)
(B)
24″
C
Acid brown soil
BROWN EARTHS
L
O
A
Ebg
Btg
30″
C
L
O
A
A/(B)
(B)g
24″
C
Surface-water gley soils
Peat
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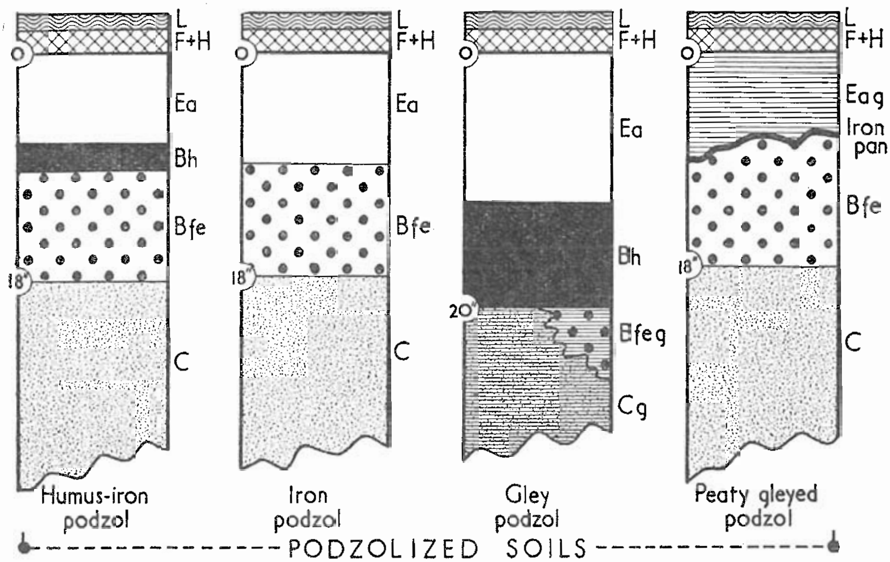
Surface-water peaty gley soil
O
Ag
8″
Cg
Ground-water gley soil
GLEY SOILS



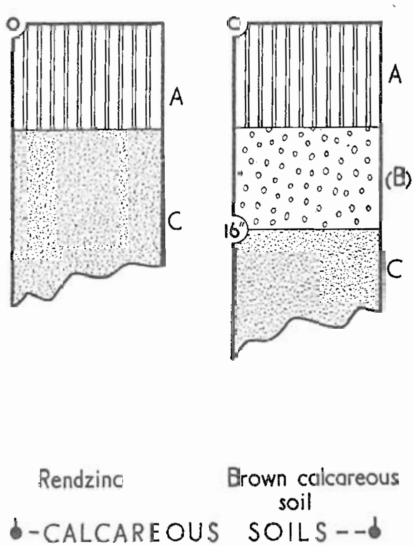


FIG. 3

Diagrammatic profiles of major soil groups and sub-groups; the symbol g (gley morphology) is represented by horizontal lines superimposed on other patterns; thicknesses of horizons are only given as a guide.

The accompanying* small-scale map of Shropshire shows the distribution of soil associations of major soil groups and sub-groups. Soil associations are defined either as areas in which different soils occur in a characteristic pattern or as landscapes with characteristic kinds, proportions and distribution of component soils. Thus the soils forming an association need not have similar properties, but do occur in close proximity.

On larger-scale maps more detail can be shown, and the soil series is used, defined as a group of soils having similar soil horizons and developed from similar parent materials. However, even on large-scale maps extreme intricacy of soil variation may prohibit the separation of soil series, and for such areas another compound unit, the soil complex, is introduced.

V. THE SOIL ASSOCIATIONS

Association 1. Leached brown soils and calcareous soils

The parent material is either Silurian (Wenlock) or Carboniferous limestone, containing more than 80 per cent calcium carbonate. These hard beds crop out in steep scarps, such as Llynclys Hill (SJ 273237) and Wenlock Edge, and form complementary dip slopes.

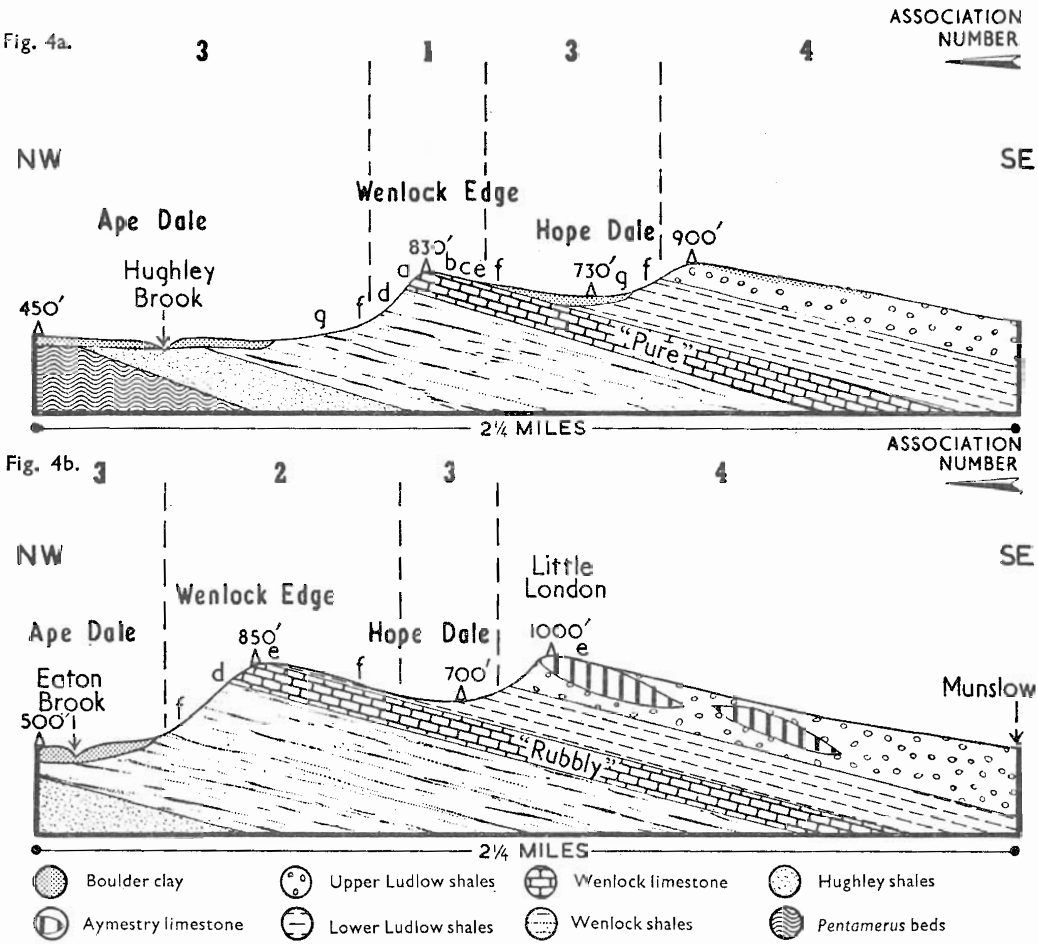
Three soil sub-groups occur: rendzinas, brown calcareous soils and leached brown soils. The first two contain calcium carbonate in the fine earth, and are nearly neutral in reaction throughout the profile. Rendzinas are rare in Shropshire, but occur on Wenlock Edge (e.g. at SO 568957) and occasionally in the north-west on Carboniferous limestone. They are characterized by a very dark A horizon of calcareous mull, lying directly on limestone at 9 inches or less, and are associated with mixed ashwood, hazel scrub or dry basic grassland. Brown calcareous soils are widespread in the association. They are somewhat deeper than rendzinas, but have a thinner A horizon above a distinct brown (E) horizon. Soils more than 15 inches thick on limestone usually have an Eb horizon and a Bt horizon of clay accumulation, are moderately acid when unlimed, and are classed as leached brown soils. A typical leached brown soil of the Wilderhope series (at SO 480876) has a dark grey-brown A horizon of acid mull 2 inches thick (pH 5·1), a light olive-brown Eb horizon 6 inches thick, with 31 per cent clay, and a yellowish brown Bt horizon with 41 per cent clay rising to 58 per cent at the junction with limestone at 17 inches. Oak, ash, hazel, dog's mercury, wood sanicle, enchanter's nightshade and woodruff (*Quercus robur*, *Fraxinus excelsior*, *Corylus avellana*, *Mercurialis perennis*, *Sanicula europaea*, *Circaea lutetiana*, *Galium odoratum*) (Clapham, Tutin and Warburg, 1962) are characteristic woodland plants.

The relationship between the soils of Association 1 and typical landscape is shown in Fig. 4a.

Association 2. Leached brown soils (sometimes with gleying)

Slightly calcareous marls and silty shales are the predominant parent materials, with prominent silt (40-65 per cent) and clay fractions (25-40 per cent). Red marls of the Downtonian crop out in Corvedale, and the broad platform surrounding the Clee Hills is composed of Dittonian marls. Hard calcareous beds of the *Psammosteus* limestone form the escarpment fringing the

* In cover-pocket.



1 Leached brown soils and calcareous soils	**3** Surface-water gley soils and leached brown soils with gleying
2 Leached brown soils sometimes with gleying	**4** Acid brown soils

a Limestone scar in places	b Rendzina	c Shallow brown calcareous soil
d Deep brown calcareous soil on colluvium	e Leached brown soil	f Leached brown soil with gleying
	g Surface-water gley soil	

Fig. 4.
Soil associations of the Silurian Scarplands.

platform, and thin, impersistent beds of fine-grained micaceous sandstone and more rarely of concretionary limestone (cornstone) occur throughout the formations (Fig. 5). Red Upper Coal Measures marls (Keele and Enville Beds) crop out in places throughout east Shropshire, accompanied by beds of medium-grained sandstone, but the outcrop of the Keuper marl is almost entirely obscured by drift. Soils of this association also occur on the shaly facies of the Wenlock and Aymestry limestones and on the intervening Lower Ludlow shales, e.g. on the Wenlock Edge dip slope (Fig 4b).

The Bromyard series occurs on Devonian (Downtonian and Dittonian) marls, and is a typical leached brown soil with a Bt horizon containing illuviated clay. The following profile was described at SO 663845 in an oakwood with ash, birch (*Betula sp.*), hazel, bramble (*Rubus fructicosus* agg.) and male fern (*Dryopteris filix-mas*). Analytical data are given in Table 2.

L ½ in. Leaf litter, mainly oak.

A 0-1 in. Dark brown stoneless silt loam; crumb and fine subangular blocky structure; abundant fine fissures; friable to slightly plastic; abundant roots; organic matter about 9 per cent (acid mull); sharp, irregular boundary.

Eb 1-12 in. Reddish brown stoneless silt loam; medium subangular blocky, becoming coarse; abundant fine fissures; friable; abundant roots (fine to 2 in.); earthworm channels; common small hard manganiferous concretions (<3 mm. diameter); merging boundary.

Bt 12-30 in. Reddish brown stoneless silty clay loam; prismatic and coarse angular blocky structure; abundant fine pores, fewer but wider fissures; plastic, compact; fewer roots; earthworm channels throughout; ped faces with clay and manganiferous coatings.

C 30 in.+ Reddish brown micaceous marl, becomes calcareous at 46 in.

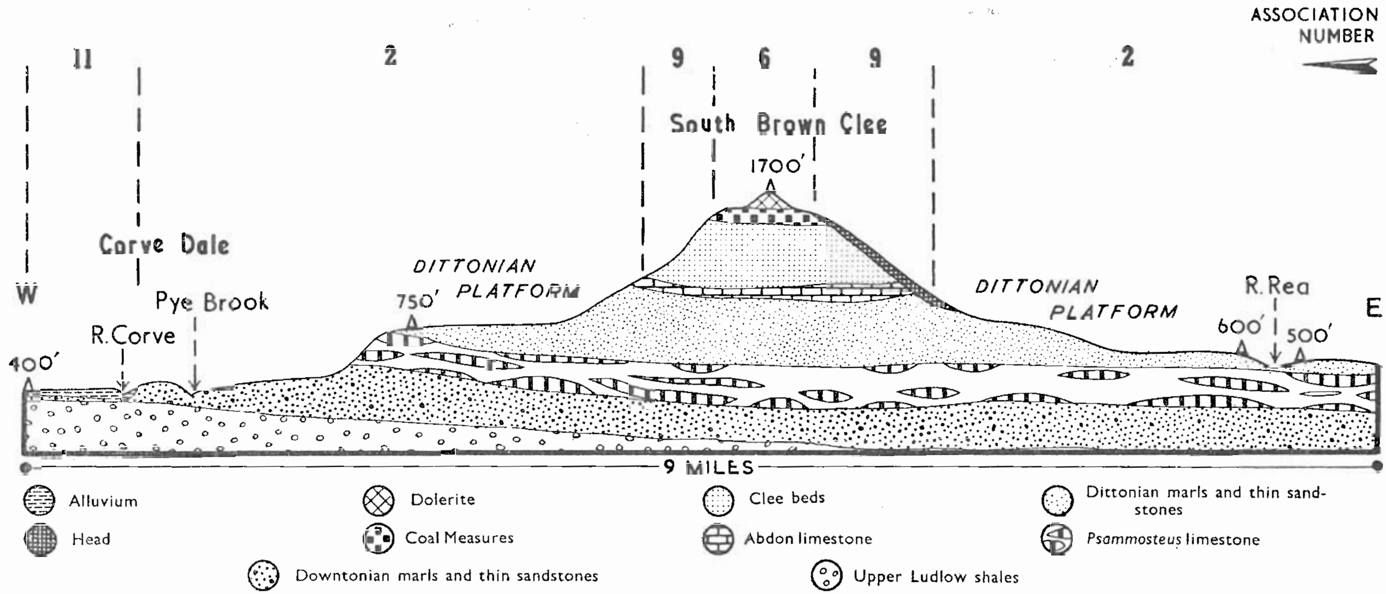
Table 2

Horizon	*Depth in.*	*Clay %*	*pH (water)*	*Base saturation %*
A	0- 1	22	4·2	17
Eb	1-12	23	4·4	5
Bt	12-30	38	5·2	62
C	30-46	28	5·9	91

The steady rise in pH and the increase in base saturation from a minimum in the Eb horizon to large values in the Bt and C horizon, and often to calcareous material at depths between 3 and 5 feet, is characteristic of leached brown soils in this district. The greater base content of the A than the Eb horizon indicates the return to the soil, through leaf fall, of bases, extracted by tree roots from the lower horizons.

A range of soils (Table 3—from Burnham, 1961) occurs on marls, depending on the site and on the calcium carbonate content of the parent material; by far the commonest is the typical leached brown soil described above.

Soils, essentially similar to leached brown soils, that are waterlogged in winter have paler Eb horizons with bright brown mottling, and are designated leached brown soils with gleying. Under woodland the mottling is usually most strongly developed at 6-12 inches, but under old grassland, which may lie wet



2	Leached brown soils sometimes with gleying (locally acid brown soils)	9	Acid brown soils
6	Surface-water gley soils (sometimes peaty) and podzolized soils	11	Brown warp soils and ground-water gley soils

FIG. 5
Soil associations of Corve Dale, the Dittonian Platform and Brown Clee.

Table 3

	Humus form	Typical pH		Vegetation	Typical locality*
Brown calcareous soil	Calcareous mull	A (B) C	6·5 7·5-8·0	Ash with oak Hazel Mercury, woodruff, etc.	Cuckoopen Coppice SO 539802
Leached brown soil	Acid mull	A Bt C	4·5 5·0 6·0	Oak with ash Hazel Bramble, male fern, etc.	Furlong Rough SO 663845
Leached brown soil (very acid)	Acid mull or moder	A Bt C	4·0 4·5 4·7	Oak with birch Bracken (*Pteridium aquilinum*), creeping soft-grass (*Holcus mollis*), bramble	Spoonhill Wood SO 614958

* Permission to examine soils should be obtained from the owner or occupier.

in winter, it occurs nearer the surface. Reddish brown acid brown soils of fine sandy loam or sandy loam texture occur on the interbedded sandstones.

Association 3. Surface-water gley soils and leached brown soils with gleying

Most of this association lies on the North Shropshire Plain, which is almost entirely covered by drift deposits of very variable thickness.

The commonest parent material is boulder clay, but small areas of soils formed from glacial lake clays, silty shales and red marls are included, the common factor being imperfect to poor natural drainage resulting from the combination of moderate or large clay content with flat or gently sloping relief.

The boulder clays were laid down by converging ice sheets, one advancing from the north carrying erratics from the Lake District, including granites, and marine shells from the floor of the Irish Sea, and another from the west carrying Welsh erratics, the probable line of junction running roughly through Ellesmere and Shrewsbury. Glacial lake clays were deposited at the margins of the ice sheets during their advance and retreat.

The boulder clay of east Shropshire consists of reddish brown sandy clays, which mainly derive their colour and calcium carbonate content (normally less than 10 per cent) from incorporation of Keuper marl. In west Shropshire the boulder clay is usually a brown or greyish brown, non-calcareous, silty clay mainly derived from Lower Palaeozoic siltstones, but in places incorporates contributions from the Trias, the red beds of the Upper Coal Measures and Carboniferous limestone. Because of these variations difficulties attend the separation of soil series. The boulder clays in the valleys of south-west Shropshire, included in this association, are grey-brown or purplish brown and contain various local rocks and erratics from Wales.

Boulder clays are interspersed with glacial sands and gravels in a complex manner, and in places are overlain by thin sandy deposits probably distributed in late glacial times.

Surface-water gley soils with A, Ebg, Btg, C profiles are more extensive than analogous leached brown soils with gleying. Most of the former have thin L, F and A horizons, followed by a greyish brown Ebg layer about 12 inches thick, with strongly contrasting orange-brown and rusty mottles, which are particularly prominent under permanent grass. The underlying Btg horizon has distinct prismatic peds, the faces of which are uniformly grey; internally, similar grey colours line root pores and minor fissures and contrast with the brown and reddish brown colours inherited from the parent material. The Btg horizon merges into the C horizon, where there is less evidence of gleying.

Observations in winter indicate that the Ebg and Btg horizons are waterlogged, water flowing from these layers when a hole is dug below their levels. Further, on grey ped faces and in pores, glistening films of water indicate the zones of penetration and stagnation of soil water. Soils with these observed water relationships and profile characters are termed poorly drained. When mottling is faint or sparse and the greyer colours produced by waterlogging are not a prominent feature, natural drainage is regarded as imperfect, and the soil is classed as a leached brown soil with gleying.

In the Wem memoir (Crompton and Osmond, 1954) imperfectly and poorly drained soils on reddish boulder clay are included in the Salop series. Undoubtedly most belong to the poorly drained class to which the series is now restricted, imperfectly drained soils being referred to the Cottam series.

A surface-water gley soil of the Salop series was described on boulder clay at SJ 583024 under mixed woodland with oak, hazel, bramble, bracken, creeping soft-grass and honeysuckle (*Lonicera periclymenum*), as well as planted beech and conifers (Table 4).

L 1½ in. Oak and beech litter.

F ½ in. Comminuted leaves, twigs and faunal droppings.

A 0-2 in. Very dark grey-brown loam; fine and medium angular blocky structure; friable, porous; moist; abundant roots; uppermost ¼ in. composed of faunal droppings, enchytraeids but no earthworms seen; organic matter about 9 per cent (acid mull).

Eb 2-5 in. Dark grey-brown stony loam; fine and medium angular blocky structure; friable to slightly plastic; moist; abundant roots and bracken rhizomes; dark patches rich in organic matter.

Ebg 5-14 in. Grey-brown stony loam with yellow and rusty mottling; coarse angular blocky structure, breaking to fine; friable to plastic; wet; abundant roots.

Btg 14-39 in. Brown stony clay loam with grey ped faces and strong brown blotches; prismatic peds with wet, sandy faces, and internally slightly moist and hard; some roots, mainly dead; grey mosaic of old root channels; soft irregular manganiferous concretions.

C 39 in. + Dull reddish brown sandy boulder clay, becoming calcareous at 51 in.

Table 4

Horizon	*Depth in.*	*Silt %*	*Clay %*	*pH (water)*	*Base saturation %*
A	0- 2	46	18	3·9	13
Eb	2- 5	44	17	4·0	n.d.
Ebg	5-14	43	19	4·3	20
Btg	14-39	46	30	4·4	47
C	39-51	45	21	6·7	94
Cca*	51-59	41	24	8·1	saturated

* 6 per cent calcium carbonate. n.d.—not determined.

A comparison of these data with those for the Bromyard series (Table 2) emphasizes the close relationship of many surface-water gley soils to leached brown soils.

Semi-natural woodlands on the soil of this association usually have the character of damp pedunculate oakwoods (Tansley, 1953).

Association 4. Acid brown soils

The Ordovician, Silurian and Devonian siltstones on which this association is found, although moderately well supplied with bases, are usually non-calcareous or deeply decalcified, and only rarely contain strongly calcareous beds. East of the fault line through Church Stretton and Hopesay, the siltstones are moderately soft and are interbedded with limestones, which form the typical scarp and vale relief of western Apedale and Corvedale (Fig. 4b). West of the fault the beds are of harder siltstones, which dip irregularly and are associated with the flat-topped hills and intervening valleys of Clun Forest and the broad ridge of the Long Mountain. In Clun Forest particularly, solifluction and colluvial deposits containing abundant tabular siltstone fragments cover the valley sides.

The acid brown soils are mostly yellowish brown coloured and of silt loam texture, without clearly defined boundaries to horizons. The (B) horizon is distinguished from the A and C horizons only by being slightly brighter yellowish brown. The soils are shallow or only of moderate depth, and in places suffer from erosion. In Clun Forest some acid brown soils are reddish brown silt loams derived from Devonian siltstones.

A soil of the Munslow series was described on Upper Ludlow siltstones at SO 496864, in an oakwood with sycamore (*Acer pseudoplatanus*), hazel, bluebell (*Endymion nonscriptus*), bramble and a little bracken (Table 5).

L 1 in. Leaf litter, mainly oak.

A 0-2 in. Very dark grey-brown silt loam with small soft siltstone fragments; very fine subangular blocky and crumb structure with earthworm and other droppings; loose, friable; abundant fine fissures; abundant fine roots; organic matter about 9 per cent (acid mull); merging boundary.

A/(B) 2-6 in. Dark grey-brown silt loam with small siltstone fragments; darker material from above in earthworm channels; very fine subangular blocky structure; loose, friable; abundant fine fissures; abundant roots; clear boundary.

(B) 6-11 in. Slightly yellower silt loam with small siltstone fragments; medium subangular blocky, breaking easily to very fine; friable; sharp boundary.

C 11 in. + Weathering olive-yellow non-calcareous siltstone.

Table 5

Horizon	*Depth in.*	*Silt %*	*Clay %*	*pH (water)*	*Base saturation %*
A	0- 2	59	8	4·7	32
A/(B)	2- 6	63	11	4·6	n.d.
(B)	6-11	59	10	4·6	13

The content of clay and of bases shows no significant tendency to rise with depth.

Semi-natural woodlands are dominated by oak and hazel, ash is infrequent; sycamore often regenerates freely. Bluebells and to a lesser extent primroses (*Primula vulgaris*) are conspicuous in spring; later in the year bracken and bramble are usually abundant, and male fern and honeysuckle are also common. Towards the west of the county birch, bracken and creeping soft-grass are frequent or abundant associates of oak.

Association 5. Acid brown soils and podzolized soils

The parent materials of this association are varied, and consist of igneous rocks and hard siltstones, sandstones, grits and quartzites of ages from pre-Cambrian to Silurian, and in addition some Carboniferous sandstones. The ridges and steep-sided valleys of such well-known landscape features as the Longmynd, Stiperstones, Caer Caradoc, the Wrekin and Pontesford Hill form a large proportion of the association, which occurs mainly in the south-west, with patches on the Shropshire Plain and on and near Titterstone Clee.

Most of the steep slopes carry well drained acid brown soils interspersed with shallow brown rankers and rock outcrops, but the gentle slopes have deeper stony soils. The Stiperstones and the Ercall are exceptional in that very stony podzolized soils predominate.

Fescue-bent (*Festuca-Agrostis*) grassland preponderates, but bracken is abundant on lower, and bilberry (*Vaccinium myrtillus*) and heather (*Calluna vulgaris*) on upper slopes. Heather and bilberry extend lower on north and west than on south and east facing slopes. Locally there are heathy oakwoods such as the Ercall and Oaks Wood (SJ 413045).

On the Longmynd plateau podzolized acid brown soils predominate, with peaty gleyed podzols locally prominent on minor ridges, and podzols wherever conglomerates crop out. The flat grassy valley floors are largely occupied by gley soils. Some hilltops in Clun Forest carry podzolized acid brown soils where heather, bilberry, bracken and, locally, grasses are common in unreclaimed areas.

The summit ridge of the Stiperstones has a dry heath association, in which heather and bilberry are dominant, with locally abundant cowberry (*Vaccinium vitis-idaea*). As a result of heather burning for the last century, however, there are large patches of 'stone desert', in places recolonized by lichens and mosses (e.g. *Polytrichum piliferum*). Burning has also destroyed the organic layers over much of the soil surface.

The Ercall, south of Wellington, is of special pedological interest. There is a close correlation between soils and geological outcrops (Fig. 6a and b), podzols occurring on strongly acid, coarse-grained rocks and acid brown soils on the more base-rich, finer-grained rocks. Except for calcareous soils, which occur in Limekiln Wood less than a mile away, all the major soil groups of Shropshire are represented in less than a square mile, for in addition to soils mentioned in the key, raw soils occur locally.

Heathy oakwoods or bracken and birch scrub are associated with podzols, whereas acid brown soils and surface-water gley soils respectively support dry and moist oak-hazel woodland.

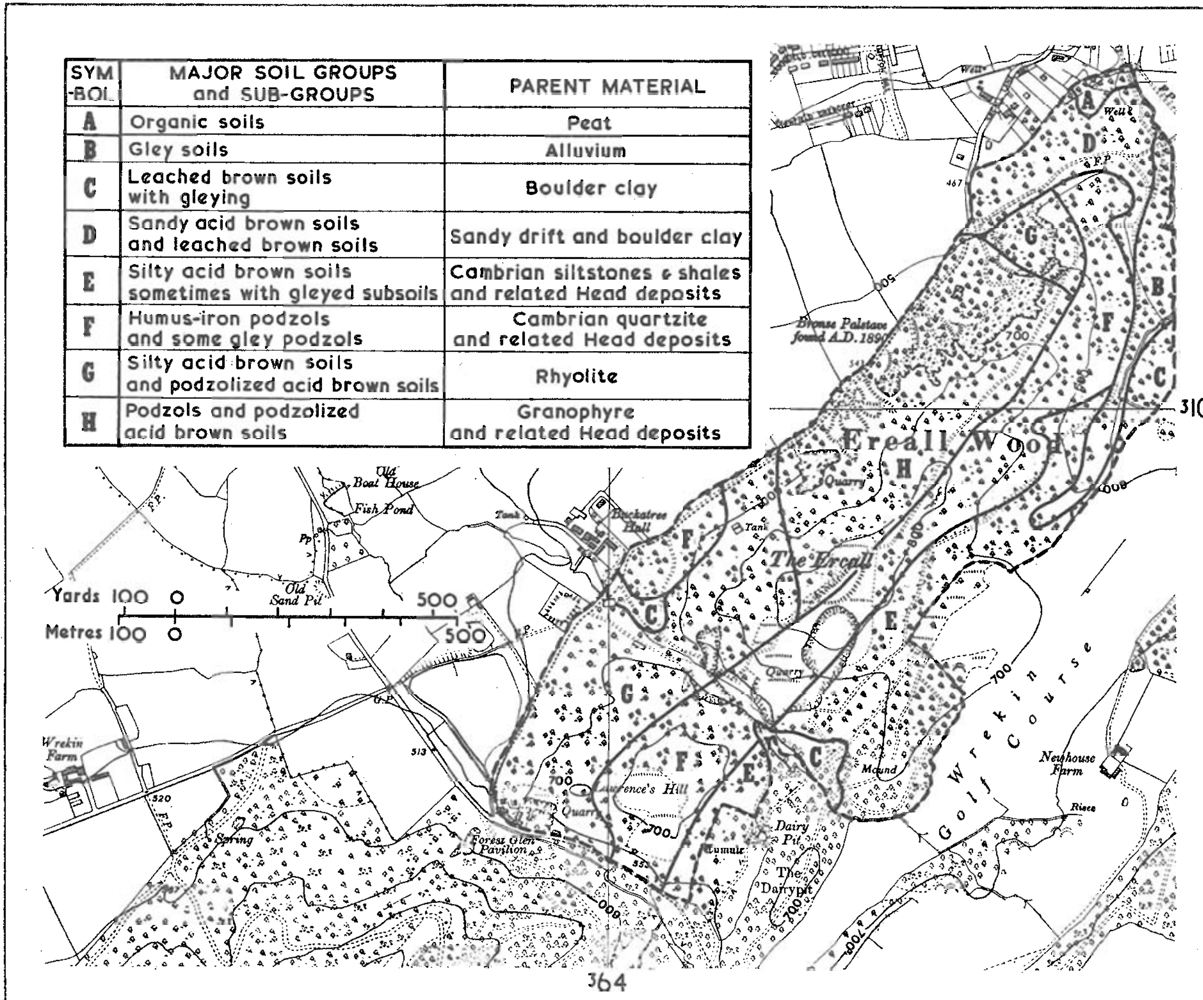
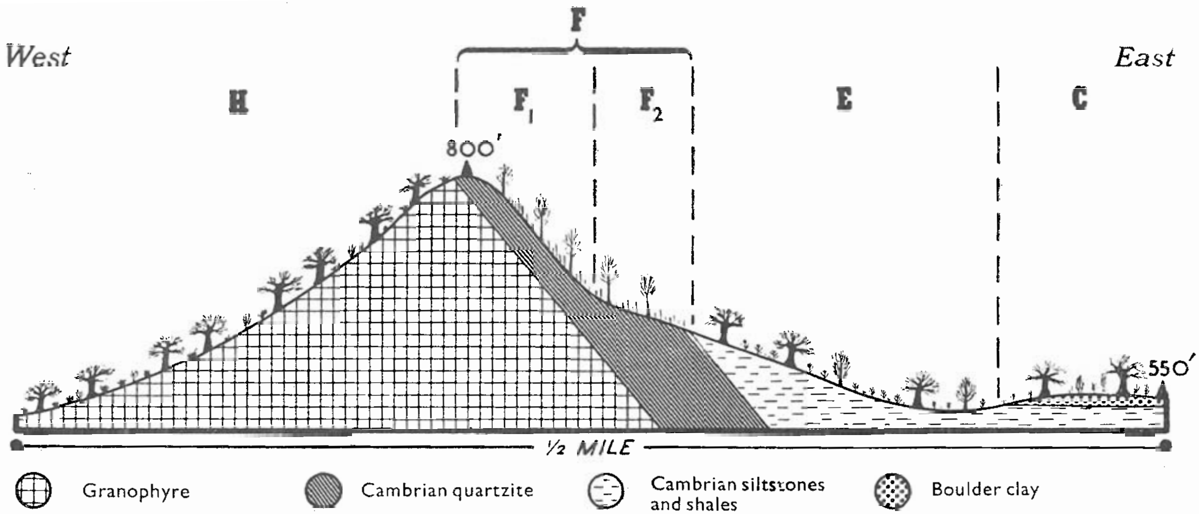


FIG. 6a.

Soils of the Ercall, Wellington, Shropshire (SJ 644097).



	Soils	Vegetation	pH Topsoil / Subsoil
H	Podzols and podzolized acid brown soils	Oak-birch coppice; heather, bilberry, bracken or wavy hair grass locally dominant	3·9 / 4·5
F_1	Humus-iron podzols and podzol rankers	Bracken, some birch scrub and heather	3·7 / 4·4
F_2	Gley podzols	Bracken, some birch and bluebell	3·8 / 4·6
E	Silty acid brown soils	Oak-birch coppice, with rowan and holly (*Ilex aquifolium*); very variable field layer including male fern, ivy (*Hedera helix*), honeysuckle, bluebell, bramble, creeping soft-grass	4·1 / 4·3
C	Leached brown soils with gleying	Mixed deciduous woodland with ash, birch, elm (*Ulmus glabra*) and alder, with hazel, hawthorn (*Crataegus monogyna*), oak and ash regenerating; field layer includes dog's mercury, enchanter's nightshade, male fern, tufted hair grass (*Deschampsia caespitosa*)	5·2 / 5·7

Fig. 6b.

Soil-vegetation relationships of the Ercall.

Association 6. Surface-water gley soils and podzolized soils

The gently sloping upland of Catherton Common, the flanks of Titterstone Clee, the summit of Brown Clee and Clun Forest, and Wild Moor on the Longmynd, each receiving between 35 and 40 inches of rainfall annually, make up this association.

On the Clee Hills, including Catherton Common, Carboniferous shales and clays are interbedded in their lower part with sandstone on which humus-iron podzols and, more rarely, gley podzols are found. Part of the shale outcrop is occupied by surface-water gley and peaty gley soils with clay or clay loam subsoils, and where it has been excavated for coal the surface is covered with hummocks and boggy hollows. Surface-water peaty gley soils of loam or silt loam texture are characteristic of Clun Forest and Wild Moor, and pass laterally into the closely related peaty gleyed podzols.

Wet heath is characteristic of the association; on Catherton Common, for example, a community of cross-leaved heath (*Erica tetralix*), heather, purple moor-grass (*Molinia caerulea*) and deer-sedge (*Scirpus cespitosus*) occupies all the damper slopes and flats where surface-water gley soils predominate, giving way to heather and bell-heather (*Erica cinerea*) or to gorse (*Ulex gallii*), bracken and wavy hair-grass (*Deschampsia flexuosa*) on drier ground often occupied by podzols. Wet heath grades through increasingly boggy vegetation to wet but still acid valley flushes, in which various rushes (*Juncus* spp.) and mosses (*Sphagnum recurvum*, *S. subsecundum*, *Polytrichum commune*) are conspicuous. Grazing (and perhaps to some extent fire and exposure) restricts the regeneration of birch and other trees.

Catherton Common is of special ecological interest, and a soil map is given in Fig. 7.

Association 7. Acid brown soils and surface-water gley soils

This association is confined to Coal Measures rocks, and occurs on the detached plateaux around Dawley (SJ 685075) and Broseley (SJ 675015), and in a long strip running south from Nordley (SO 695968) into the Wyre Forest, an ancient woodland of great interest. The present extent of the forest is about 10 square miles, rather less than half of which is in Shropshire, and consists of a plateau with a summit level between 450 and 500 feet, strongly dissected by the valleys of the Severn, Dowles Brook and their minor tributaries. It is almost entirely underlain by yellowish medium-grained sandstones and grey and reddish shales of Middle Coal Measures age. A superficial layer of Head (a solifluction deposit formed under periglacial conditions) is usually present, varying in thickness from less than 2 feet to more than 5 feet. Apart from a thin band of *Spirorbis* limestone, all the parent materials have a small base content.

Yellowish brown acid brown soils with A, A/(B), (B), C profiles of sandy loam or loam texture, occur on sandstone and Head. The shale outcrops are marked by soils with subsoil gleying, which occurs at a depth dependent on the site and the thickness of overlying Head. There are very occasional podzolized soils, in which a pale yellowish brown Ea horizon, not completely depleted of iron, overlies a bright brown Bfe horizon. Where the Head is thick, there is a characteristic subsoil layer at depths ranging between 1 and 3 feet in which there is relatively little fine earth between the sandstone fragments. Below, the

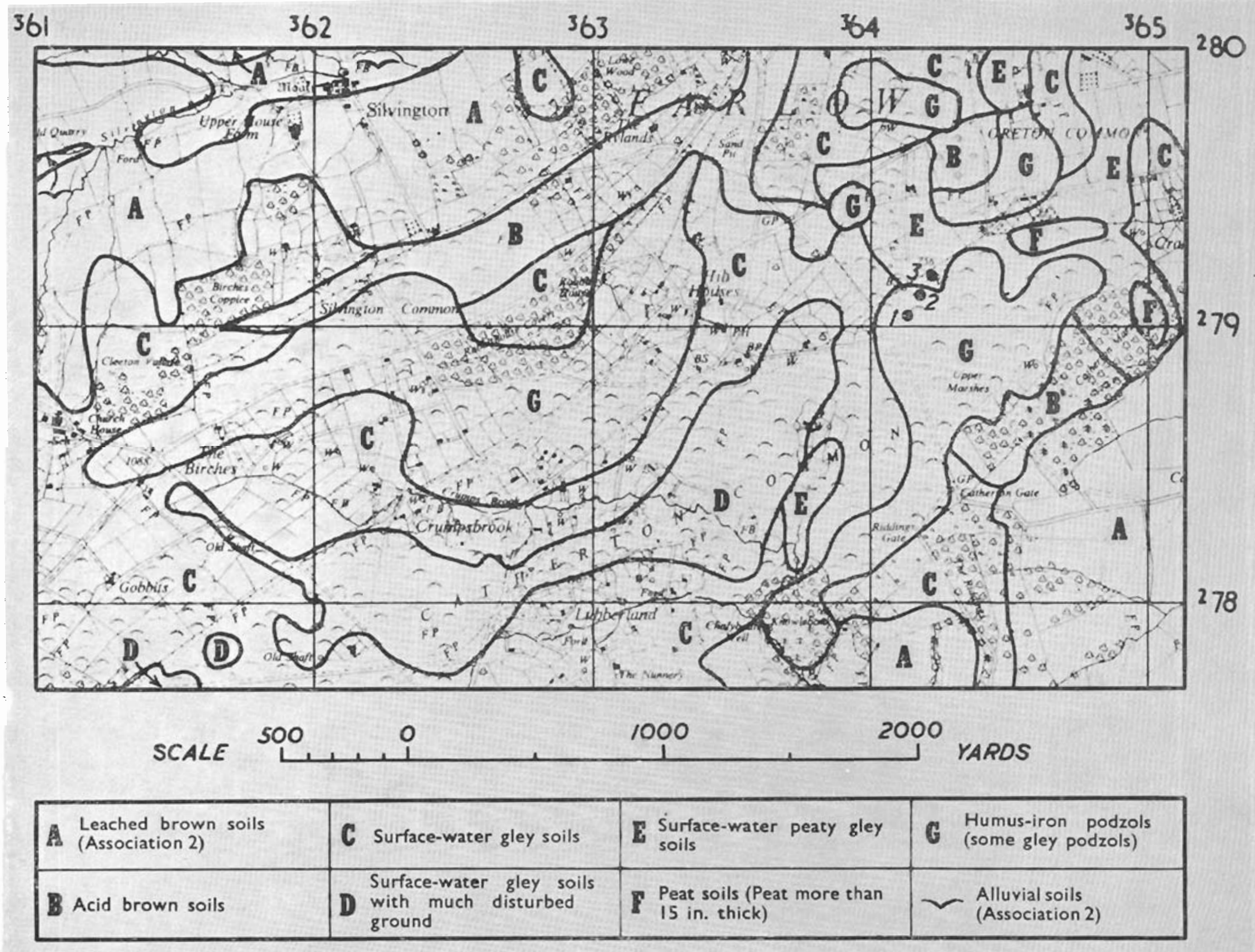


FIG. 7

Soils of Catherton Common, near Ludlow, Shropshire and surrounding areas. Near SO 642790 are a humus-iron podzol (1), a gley podzol (2) and a peaty surface-water gley soil (3).

interstices are partly filled, and thin coatings of reddish clay occur on some sandstone surfaces, indicating that at some time there has been mechanical eluviation of fine particles.

The small base content of the soils is reflected in the semi-natural vegetation of sessile oakwood (*Quercus petraea*) with a ground flora of creeping soft-grass, heather, bilberry, wavy hair-grass, bracken and bramble (Salisbury, 1925). Near streams, restricted areas have been enriched by flushing and carry dog's mercury and other base-demanding herbs. For many years oak in Wyre Forest was coppiced on a 16-18 year rotation; in some places the Forestry Commission have selected stems for a standard crop, but growth is slow. Much of the oak is interplanted with beech, and elsewhere Japanese and European larch are planted extensively, with smaller areas of Corsican pine and Douglas fir. Where oak is accompanied by a ground flora which includes bilberry and heather the humus form is usually thin moder, the L and F layers together being about 1 inch, beneath which a black, well-decomposed H layer 1 to 1½ inches thick rests directly on the mineral soil.

Association 8. Podzols and gley podzols

The highly quartzose, base-deficient glacial sands of north Shropshire, containing less than 15 per cent and often less than 5 per cent clay, form the parent materials of Associations 8 and 9. Association 8 consists of scattered areas of podzolized soils under heath or heathy woodland, together with cultivated land reclaimed in the last 200 years. It contrasts with the more extensive sandy acid brown soils of Association 9 which have been cultivated for a longer period.

Humus-iron podzols and gley podzols are equally extensive; the former are commoner in better-drained sites where sands and gravels overlie boulder clay or sandstone, and the latter in flat or depressed sites underlain by boulder clay (Fig. 8). Mackney (1961) discussed the relationships of well-drained podzolized soils on sandy deposits.

Davies and Owen (1934) described a typical humus-iron podzol from Goldstone Common (SJ 700290) under heathy oakwood, and selected data are given in Table 6.

L+F	6 in.
H	3 in. Almost black, well humified organic matter mixed with bleached sand and pebbles.
Ea	0-10 in. Pale grey, loose, pebbly sand.
Bh	10-14 in. Black, compact, humose sand.
Bfe	14-26 in. ¼ in. thick cemented iron pan followed by orange-brown, compact sand, with numerous pebbles; intensity of colour decreases with depth.
C	26 in. + Pebbly reddish brown sand, passing to soft sandstone.

Table 6

Horizon	*Depth in.*	*Organic matter %*	*% Fe_2O_3 in clay fraction*	*Clay %*	*pH (water)*
H		25		3	3·7
Ea	0-10	3	3	1	3·2
Bh	10-14	12	5	9	3·7
Bfe	14-26	1	16	2	4·8
C	26+	nil	10	3	4·8

Gley podzols are extensive on certain heaths, notably Prees Lower Heath (SJ 570320), Stanton Heath (SJ 590230) and Shawbury Heath (SJ 540200). They are podzols affected by ground-water, the waterlogging is mainly from the impermeability of the underlying boulder clay which is at no great depth. Compared with well drained podzols the organic horizons are thicker and tend to be peaty; the Ea horizon is thicker, and, although the Bh horizon is thicker and more strongly cemented, the Bfe horizon is absent or discontinuous or may be expressed only by rusty mottling below the Bh horizon. The field relationships of the soils in this association are illustrated by a section from Hodnet Heath (Fig. 8).

The soil map of the Wem district includes both gley podzols and humus-iron podzols in the Crannymoor series.

In the dry heathy areas of humus-iron podzols, heather and/or bracken are dominant and wavy hair-grass is subordinate. Although re-establishment of trees is often checked by grazing and periodic fires, some birch regenerates, and where grazing or burning no longer occurs deciduous woodland of oak and birch with some rowan and holly can become established. The ground flora under deciduous woodland is dominated either by bracken or wavy hair-grass, with heather in more open places. Bilberry occurs only occasionally. Gley podzols are associated with wet heath in which cross-leaved heath, purple-moor-grass and rushes accompany heather. The area of both wet and dry heath in north-west Shropshire has been very much decreased by reclamation during the past hundred years, and probably the surviving examples hardly give a fair picture of the former vegetation.

Association 9. Acid brown soils and podzolized soils

This association extends over much of the northern part of the county. The parent materials are coarse-grained superficial deposits and sandstones, the former being the most widespread and consisting of stratified and unstratified sands and gravels, together with poorly sorted morainic materials. The sandstones are mainly relatively soft reddish brown strata of Bunter and Keuper age, the Devonian sandstones and Pleistocene Head around Brown Clee and near Farlow (SO 640807) being of restricted extent.

The broad rolling landscapes are dissected by streams, or consist of broken hummocky terrain, mostly below 400 feet, above which protrude low sandstone ridges such as Nesscliff Hill (SJ 386198), Grinshill Hill (SJ 520239), and Hawkstone (SJ 579293). In striking contrast is the deeply dissected country around Bridgnorth and Worfield (SO 758958) associated with the rivers Severn and Worfe, and the upland area, mostly above 1,000 feet, surrounding Brown Clee.

The predominant soils are well drained acid brown soils of the Newport series with A, A/(B), (B), C or Ap, (B), C profiles developed on slightly stony glacial sands. The profile consists of brown loamy sand or sandy loam overlying brighter brown loamy sand or sand. Related stony or very stony soils of the Baschurch series are dispersed throughout the landscape but are particularly frequent south of Ellesmere. In places acid brown soils are accompanied by podzolized soils, particularly in woodlands, and may adjoin surface-water gley soils where boulder clays and glacial sands and gravels interdigitate.

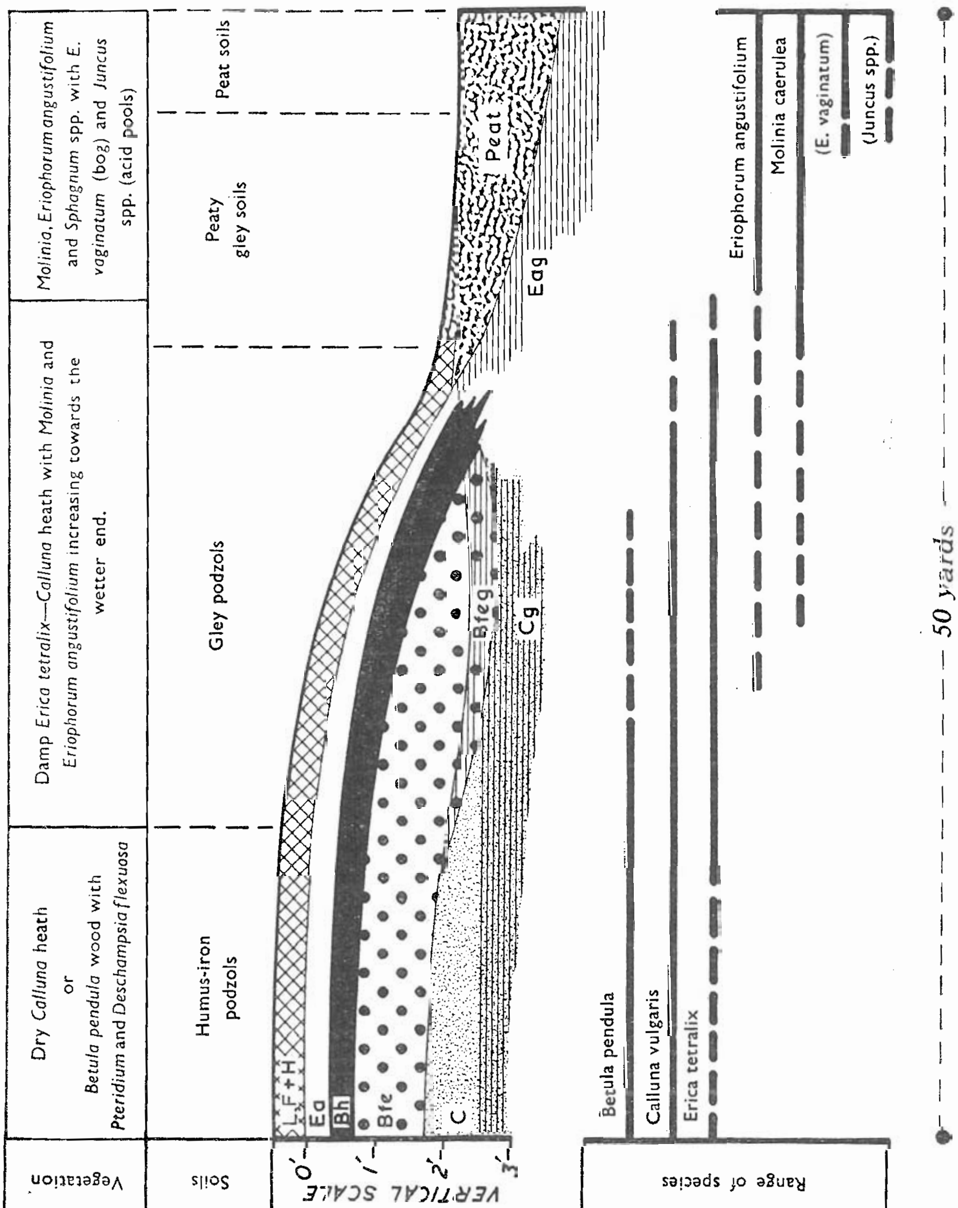


FIG. 8

Soil-vegetation relationships at Hodnet Heath (SJ 620265).

On sandstone ridges rising steeply out of the drift-covered plains and around Bridgnorth and Worfield, reddish brown, sandy acid brown soils of the Bridgnorth series are common, the steep slopes often bearing shallow soils and some bare rock.

In east Shropshire near Beckbury (SJ 765015), Shifnal and Newport, most of the superficial deposits are thin, and sandy acid brown soils on Trias sandstones are scattered among similar soils on glacial sands and gravels.

Acid brown soils of the Liberty series are common on the western flanks of Brown Clee, and similar soils, containing dolerite boulders derived from the summit, occupy the eastern flanks. The soils are naturally acid or strongly acid, supporting either dry oak-birch woodland or bracken heath, in which birch, often accompanied by rowan (*Sorbus aucuparia*), regenerates.

Association 10. Peat and peaty soils

The till-covered plain of north Shropshire has numerous closed hollows, many of which contain peat (Sinker, 1962). Where the peat developed in contact with ground-water (fen or low moor) its reaction is not strongly acid (pH 5·5 or higher), and remains of reeds, or, in places, of a swampy woodland (carr) of oak, alder (*Alnus glutinosa*), willow (*Salix* spp.) and birch, predominate; the Berth (SJ 430235) and Burlton Moss (SJ 465270) are of this type. A closely-related group, formed in broad flat parts of river valleys (valley mires), includes alluvial soils and peaty loams as well as fen peat, and is represented by Baggy Moor (SJ 390770), Boggy Moor (SJ 410260) and the Weald moors (SJ 670180). In certain closed hollows much more acid *Sphagnum* peat (pH 3—5) has developed above fen peat, forming raised mosses, such as Whixall Moss (SJ 490360) and Smithy Moor (SJ 410310).

By effective regional drainage, organic soils can be reclaimed for arable use but, apart from the Weald moors, most of the Shropshire peats remain uncultivated. With less intensive drainage, fens and valley mires can become pasture or meadow, and on raised mosses the growth of *Sphagnum* ceases, and heather, purple moor-grass and cotton-grass (*Eriophorum angustifolium*) become dominant, with some birch in places.

Association 11. Brown warp soils and ground-water gley soils

Most soils on young alluvial deposits of the flood plains are of medium to fine texture, are seldom strongly acid, and show great variation in natural drainage. Well-drained brown warp soils rarely show much development apart from A or Ap horizons, though deposition layers may be evident. Imperfectly-drained associates have some grey and rusty mottling either below 18 inches or weakly expressed throughout the profile. Ground-water gley soils with prominent grey subsoils and rusty mottling near the surface are widely distributed.

The soils are mainly under grass, and woods are frequent only along minor streams. Where waterlogging is confined to the subsoil, pedunculate oakwood with mull occurs, while alder and willow grow on the river banks. In wetter sites, alder may share dominance with oak, and organic matter tends to accumulate at the surface.

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REFERENCES

AVERY, B. W. (1956). A classification of British soils. *Trans. 6th Int. Congr. Soil Sci.*, **5**, 279-285.
BURGES, A. (1958). *Micro-organisms in the Soil*. London.
BURNHAM, C. P. (1961). *The Soils of the West Midlands (Classification and Properties)*. M.Sc. dissertation, University of London.
CLAPHAM, A. R., TUTIN, T. G., and WARBURG, E. F. (1962). *Flora of the British Isles*. 2nd Edition. Cambridge.
CLARKE, G. R. (1957). *The Study of the Soil in the Field*. 4th Edition. Oxford.
CROMPTON, E., and OSMOND, D. A. (1954). The Soils of the Wem District of Shropshire. *Mem. Soil Survey of England and Wales*. H.M.S.O. London.*
DAVIES, W. M., and OWEN, G. (1934). Soil survey of North Shropshire. *Emp. J. Exp. Agric.*, **11** (1), 178–188
DUCHAUFOUR, P. (1960). *Précis de Pédologie*. Paris.
KLINGEBIEL, A. A., and MONTGOMERY, P. H. (1961). Land Capability Classification. *U.S. Dept. Agric. Handbook* No. 210. Washington, D.C.
KUBIENA, W. L. (1953). *Soils of Europe*. London.
KÜHNELT, W. (1961). *Soil Biology*. London.
MACKNEY, D. (1961). A podzol development sequence in oakwoods and heath in Central England. *J. Soil Sci.*, **12**, 23–40.
MACKNEY, D., and BURNHAM, C. P. (1964). Soil Map: Sheet 166 (Church Stretton). Ordnance Survey.
MACKNEY, D., and BURNHAM, C. P. (in the press). *The Soils of the West Midlands*.
PENMAN, H. L. (1950). Evaporation over the British Isles. *Quart. J. Roy. met. Soc.*, **76**, 372–383.
ROBINSON, G. W. (1912). *A Survey of the Soils and Agriculture of Shropshire*. Shrewsbury.
SALISBURY, E. J. (1925). The vegetation of the Forest of Wyre, a preliminary account. *J. Ecol.*, **13**, 314–321.
SINKER, C. A. (1962). The North Shropshire meres and mosses: a background for ecologists. *Field Studies*, **1** (4), 101–138.
SOIL SURVEY STAFF (1960). *Soil Survey of Great Britain: Field Handbook*.*
TANSLEY, A. C. (1953). *The British Islands and their Vegetation*. Cambridge.
UNITED STATES SOIL SURVEY STAFF (1951). Soil Survey Manual. *U.S. Dept. Agric. Handbook* No. 18. Washington, D.C.
WHITTARD, W. F. (1952). A geology of South Shropshire. *Proc. Geol. Ass. Lond.*, **63**, 143–197 (full references).

FURTHER READING

DINELEY, D. L. (1960). Shropshire geology: an outline of the tectonic history. *Field Studies*, **1** (2), 86–108.
EDMUNDS, F. H., and OAKLEY, K. P. (1947). The Central England District. *British Regional Geology*. H.M.S.O. London.
GEOLOGICAL SURVEY. Memoirs for the Oswestry (137), Wem (138), Shrewsbury (152), Wolverhampton and Oakengates (153), and Dudley (167) sheets.
POCOCK, R. W., and WHITEHEAD, T. H. (1948). The Welsh Borderland. *British Regional Geology*. H.M.S.O. London.
RUSSELL, E. J. (1961). Revised by E. W. Russell. *Soil Conditions and Plant Growth*. 9th Edition. London.
RUSSELL, E. J. (1957). *The World of the Soil*. London.

* Obtainable from the Soil Survey of England and Wales, Rothamsted Experimental Station, Harpenden, Herts.

Appendix I *The ecological characters of the soil associations*

Table 7.

Association No.	*Major soil group and sub-group*	*Elevation*	*Natural acidity of soil* — *Surface*	*Natural acidity of soil* — *Subsoil*	*Soil moisture and drainage conditions*	*Typical semi-natural vegetation*	*Typical humus form*
1	Leached brown soils . .	M	5·0-6·5	6·5-8·0	Moist (F)	Oak-Ash-Hazel	Acid mull
	Calcareous soils . .		6·0-7·5	6·5-8·0	Dry or moist (F)	Ash-Oak-Hazel	Calcareous mull
2	Leached brown soils . . (sometimes with gleying)	M	4·0-6·0	5·0-7·0	Moist (F-I)	Oak-Ash-Hazel	Acid mull
3	Surface-water gley soils	L	4·0-5·0	5·0-6·5	Wet (P)	Oak-Ash-Hazel	Hydromorphic moder or acid mull
	Leached brown soils with gleying				Moist (I)		Acid mull
4	Acid brown soils . .	M	4·0-5·2	4·5-5·8	Dry (F)	Oak-Hazel	Acid mull
5	Acid brown soils . .	H	3·5-5·0	4·5-5·5	Dry (F)	Oak-Birch or acidic grassland with bracken	Moder Moder, sometimes mor
	Podzolized soils . .					Heather-Bilberry	Mor
	Brown rankers					Fescue-Bent	Acid mull or moder
6	Podzolized soils . .	H	3·5-4·5	4·2-5·5	Dry (F)	Dry Heath	Mor
	Surface-water gley soils				Wet (I-VP)	Wet Heath	Hydromorphic moder or mor or thin peat
7	Acid brown soils . .	M	3·7-5·0	4·5-5·5	Dry (F)	Oak-Birch	Thin moder or acid mull
	Surface-water gley soils				Moist (I-P)		
8	Podzols	L	3·1-4·5	4·5-5·0	Very dry (F)	Heathy Oak-Birch or dry Heath	Thick moder or mor
	Gley podzols				Moist (I)	Wet Heath	Mor

9	Acid brown soils and podzolized soils ..	L	4·0-5·0	4·8-5·8	Dry (F)	Oak-Birch or Bracken	Acid mull or moder
10	Peat soils (raised moss)	L	3·0-4·7	3·5-5·0	Very wet (VP)	Sphagnum moss, birch and pine when drained	Moss peat
	Peat soils (fen peat) and peaty soils	L	5·0-7·0	5·5-7·0	Very wet (VP)	Rushes and sedges or Carr-type alderwood	Fen peat
11	Brown warp soils ..	L	4·5-6·0	5·5-7·0	Moist (F-I)	Oak-Alder	Acid mull
	Ground-water gley soils	L	4·5-6·0	5·5-7·0	Wet-very wet (P-VP)	Oak-Alder	Acid mull or hydromorphic moder

Table 7—to which the following notes refer—summarizes the remarks in the text regarding the ecological characters of the associations described.

Typical elevation:

H—High (over 800 ft.) Generally associated with an average annual rainfall of over 35 in.

M—Moderate (400–800 ft.) Generally associated with an average annual rainfall of 30–35 in.

L—Low (under 400 ft.) Generally associated with an average annual rainfall of under 30 in.

Natural acidity of soil:

Typical pH values fall within the limits given.

Subsoil implies near the limit of root range, either at 24–36 in., or, in shallow soils, immediately above unaltered parent material.

Natural drainage of soil:

This is inferred from a consideration of several soil properties.

F—Free or moderately free.
I—Imperfect.
P—Poor.
VP—Very poor.

Soil moisture conditions in woodland and heath depend partly on natural soil drainage, but also partly on the moisture-absorbing power of the soil, the latter generally a function of texture.

APPENDIX 2 *The agricultural characters of the soil associations*

Table 8.

Association No.	*Major soil group and sub-group*	*Surface texture*	*Need for: Drainage*	*Need for: Lime*	*Site factors*	*Land capability grading*	*Most suitable crops*	*Typical farming system*
1	Leached brown soils ..	Medium or silty	Rarely	Infrequent	M	II	C G	Mixed
	Calcareous soils ..			Never	M S	III VI	C G W G	
2	Leached brown soils (sometimes with gleying)	Silty	Sometimes	Regular	L M S	I-II II VI	C G (F) (R) C G W G	Mixed
3	Surface-water gley soils	Heavy or medium	Usually	Regular	L/M H	III IV	G (C) G	Mixed or dairying Rearing
	Leached brown soils with gleying				L/M	II	C G (R)	Mixed or dairying
4	Acid brown soils ..	Silty	Rarely	Regular	M H S	II III VI	C G G (C) W G	Mixed or rearing
5	Acid brown soils and podzolized soils ..	Medium or silty	Rarely	Regular	H S	IV-VI VI-VII	W G	Rearing
6	Surface-water gley soils and podzolized soils ..	Medium or heavy	Usually	Regular	M H	IV IV-VII	W G	Rearing
7	Acid brown soils and surface-water gley soils	Medium or heavy	Sometimes	Frequent	M	III	G W (C)	Mixed
8	Podzols and gley podzols	Light	Rarely	Frequent	L	III	C R (V)	Arable
9	Acid brown soils and podzolized soils ..	Light or medium	Rarely	Frequent	L	I-II	C R V (F)	Arable
					M H	II-III III-VI	C G W G	Mixed
10	Peat soils (raised moss)	Organic	Always (Regional)	Frequent	L	I-II	R C V G	Arable (if drainage effective)
	Peat soils (fen peat) and peaty soils			Variable				
11	Brown warp soils and .. ground-water gley soils	Heavy or silty	Usually. Not liable to flood	Infrequent or Regular	L	II-III	G (C) (R)	Mixed or rearing
			Always (Regional). Liable to flood.		L	IV-V	G	Rearing

Table 8—to which the following notes refer—summarizes the agricultural properties of the associations.

Texture:
Light—sand and loamy sand.
Medium—sandy loam, loam and sandy clay loam.
Silty—silt loam and silt.
Heavy—clay loam, silty clay loam, sandy clay, silty clay and clay.

Need for dressings of lime:
Infrequent—On average less often than once every 10 years.
Regular—On average once every 5–10 years.
Frequent—On average more often than once every 5 years.

Mineral deficiencies:

These must be corrected by the use of appropriate fertilizers. Of the major nutrients nitrogen requirements are little affected by soil, and phosphate is needed regularly by all soils except those in Association 9 which have had frequent applications for some years. Potash is widely used except for the soils in Association 2 which are sufficiently supplied with this nutrient for cereals and grass. Among minor elements needed by plants, manganese is frequently deficient in soils of Association 10, and applications of magnesium, manganese and boron are required on most soils in Association 8 and some of the sandiest soils in Association 9.

Site factors (only elevation and slope are considered)*:*
L—Under 400 ft. O.D.
M—400–800 ft. O.D.
H—Over 800 ft. O.D.
S—On slopes steeper than 20°.

Land Capability Grading:

In studies of land use an estimate of land quality is often desired, for which properties of climate, site and soil must be taken into account. One system that can be used is the United States Department of Agriculture Land Capability Classification (Klingebiel and Montgomery, 1961). Adaptability to a wide range of crops and ease of management are considered together with yield to give four grades of soils suited to cultivation and other uses (Classes I-IV), whilst land impractical to cultivate is graded in Classes V-VIII.

Most suitable crops:

C—Cereals	G—Grassland (permanent pasture or long leys)
R—Root crops	
V—Market-garden crops	W—Forestry
F—Fruit	

Brackets indicate that crops are only sometimes suitable.

Additional Notes:

Association 3. Some surface-water gley soils of the Wem series rate as Class II where there is effective drainage.

Associations 5 and 6. Frequent applications of lime are necessary to maintain neutral conditions, but would not be economic.

Associations 8 and 9. Sand and loamy sand soils may warrant a higher grading if irrigation is practicable.

Association 9. Sandy loams rate Class I, sands and loamy sands Class II.

Association 11. The value of these soils depends upon the natural drainage of the soil, the effectiveness of artificial drainage and the incidence of flooding. Some are used as fattening pastures.