

THE NATURAL HISTORY OF SLAPTON LEY NATURE RESERVE, XVI: THE SOILS OF SLAPTON WOOD

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ABSTRACT

The soils of Slapton Wood are reddish silty brown earths which grade into a brown podzolic soil (with a darker red colour and a more discrete, darker organic matter horizon). Soil parent materials, soil characteristics and development are discussed.

INTRODUCTION: SOIL FORMATION

THE SOILS of Slapton Wood are acid and nutrient-poor, with a high content of silt-sized particles and fragments of weathered slate. They have a strong red-brown colour.

The soils are acid and nutrient poor because they are developed from a parent rock which contains a low level of nutrients. In addition, a moderately high rainfall, about 1100 mm a⁻¹, acts to wash soluble nutrients down through the soil, a process known as leaching.

The bedrock is a lower Devonian slate, approximately 390 million years old, originally composed of muds of low nutrient content. The muds have been compressed and metamorphosed into slates. The dominant minerals present are quartz and kaolinite. These minerals are very stable and are often regarded as the stable end product of weathering. During weathering, the minerals release small amounts of silica and aluminium but very little in the way of important plant nutrients such as calcium and magnesium.

A significant constituent of the rock is iron and this may be present in the oxidised (iron III) or reduced (iron II) form. Although not of primary significance as a plant nutrient, the presence of iron has a strong influence on the colour of the soil. Oxidised iron is a reddish (rusty) colour and reduced iron is greeny-grey. Some of the slates have a greeny-grey-tinge showing that here, the iron is present in the reduced form. Other slates are more purplish and here the iron is present in the oxidised form. During weathering and soil formation the chief process operating is the oxidation of iron, which gives rise to the red colour of the soil. The oxidation is chiefly the result of the exposure of the iron to the air but biological processes may also be involved, especially oxidation by some micro-organisms in the soil. Obviously, a purplish coloured slate is already oxidised and will tend to be more stable than the greeny-grey slate where the iron is reduced and unstable in the presence of air.

Weathering of slate is active at the present time, as it was during the recent geological past, the red colour of much of the Devonian soils and rocks near the surface is often thought to have been in part derived during strongly oxidised desert weathering conditions which occurred during the Triassic period, about 200 million years ago.

During the Pleistocene glaciations, south Devon was not covered by ice, but was at the margins of the ice sheets, as deduced by the evidence of glacial drift deposits in north Somerset and along the Bristol Channel coast. Therefore, in south Devon, weathered deposits were not moved by glacial erosion and the soils are developed

from local material rather than from glacial drift. However, as the area was near the ice margin, seasonal frost action was intense during the Pleistocene giving rise to frost-heaving of the slates during freezing and slumping and flow of wet weathered material downslope during thawing: processes collectively termed periglacial processes, that is processes peripheral to, or around, glacial areas. Thus, frost shattered and solifluction (soil-flow) deposits may often be seen in the area (Mottershead, 1971; Waters, 1971). In addition, wind-blown deposits, termed loess, derived from wind erosion of vegetation-free areas of glacial deposition may be found in ice-margin areas. Thin loess deposits are found widely in southern England, but their contribution to soil formation in the study area is not certain.

The parent materials of the soils may thus be either deeply weathered profiles developed over long periods of time *in situ*, without any glacial removal or deposition, or periglacially modified deposits, including frost-disturbed and slope-foot solifluction deposits. In addition, there are deposits of river alluvium in the valley bottoms. Long-term, uninterrupted weathering has tended to produce deep soils of 1–2 m depth, even on some of the steeper slopes.

In the study area, the Devonian slates are differentiated into the Meadfoot beds and the Dartmouth slates (Dineley, 1961; Mercer, 1966). The Dartmouth slates are older and outcrop in the northern and central parts of the study area (Figure 1), with the younger Meadfoot beds outcropping to the south. The Dartmouth slates are recorded by the Geological Survey as containing both purple and green slates and they would appear to be more resistant to erosion than the Meadfoot beds, giving rise to steeper slopes in the area where they outcrop. The strike of the rocks is approximately ENE, with the Meadfoot beds dipping at around 20–25° SSE over the older Dartmouth slates. In practice, in the weathered sections available for study in the area, the two are difficult to distinguish.

SOIL CHARACTERISTICS

Comprised originally of silts, the slate rock breaks down to yield a soil with abundant silt-sized particles, about 0.02–0.002 mm in diameter. Clay is also present, derived from the parent rock or formed within the profile during weathering. Small and large stones of slate are also often abundant in the soil profile, with many slate fragments of sand size.

Commonly, the soils have 30–40% silt and 30–40% clay. Soils with these proportions of silt present may be prone to compaction under cultivation and trampling by stock, especially if the soil structures are weak. Under pressure, silt particles can be packed close together and, in the agricultural areas around Slapton Wood, it is common to find that the soil is more compacted at the surface than at depth. This is especially evident in gateways where poaching by cattle is common.

Clays have negatively charged surfaces where nutrient cations, such as calcium (Ca^{++}) and magnesium (Mg^{++}) may be held. Here, they are available for plant nutrition and are not readily lost by leaching. Silts have much fewer charged sites on their surfaces than clays and are therefore less retentive of cations. Thus, during leaching, cations may be readily lost from silt soils, rendering them more acid and less fertile. This, and the nature of the rock type with the moderate rainfall mentioned above, have combined over long periods of time to produce leached, acid soils, commonly with pH values in the range of 4–5.

The soils in the area are thus dominantly acid, silty and of a reddish, oxidised

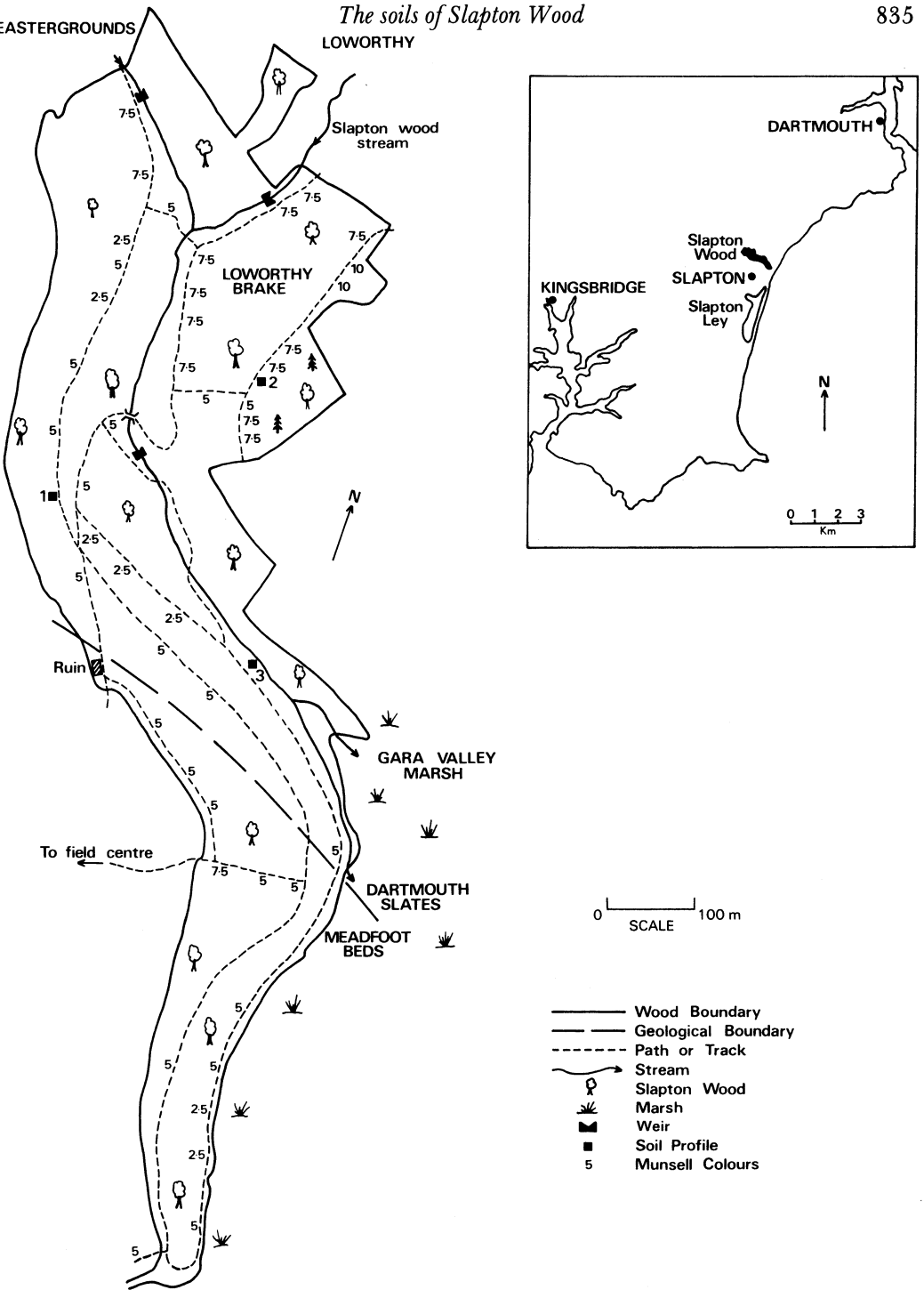


FIG. 1.

Slapton Wood. Location of profiles 1-3 (Tables 1-3). Munsell Colour Notation 2.5, 5, 7.5 and 10 as follows:

- 2.5 YR — red
- 5 YR — reddish yellow and yellowish red
- 7.5 YR — reddish yellow-strong brown
- 10 YR — brownish yellow-yellowish brown

2.5 YR — brown podzolic soils (especially 2.5 YR with darker humus)

7.5-10 YR — brown earths

5 YR soils — intermediate, mostly reddish coloured brown earths, with darker discrete humus.

colour. In soil type they range from an acid brown earth towards a more podzolic soil. In waterlogged valley bottoms, a somewhat different waterlogged, gley soil occurs, where the soil is not freely oxidised. These soils are described below.

Brown earths and brown podzolic soils

The transition from a brown earth to a brown podzolic soil is marked by (1) an increase in the depth of a dark, discrete, raw acid humus accumulation on the top of the mineral soil profile (the term discrete meaning that it is distinct from the mineral soil and not well mixed); and (2) an increase in redness of the soil due to the alteration of minerals in the soil profile *in situ* and the release of iron. A true podzol is not present; this has a bleached eluvial mineral horizon below the humus layer, which is not apparent in the soils of the study area. However, careful inspection of the humus layer in Slapton Wood may reveal the presence of a few scattered bleached quartz grains in the humus layer; this is often seen as evidence of incipient podzolisation. In addition, the upper portions of the mineral soil may appear to be a paler colour than the rest of the profile, again diagnostic of incipient podzolisation.

The brown earth has a more well-mixed humus mineral layer, usually because it is less acid than a podzolic soil and biological activity is greater. The population of earthworms and other organisms is greater in less acid soils and their activity is responsible for the breakdown of organic matter and its incorporation and redistribution within the soil profile. Under more acid conditions, organic breakdown and incorporation in the soil is limited. This gives a more discrete (separate) humus layer on top of the mineral soil.

Within Slapton Wood, soils grade from an acid brown earth to a brown podzolic soil. In practice, they are difficult to distinguish unless a large number of soil profiles are studied and compared. However, the brown earth is characterised by a browner humus than the brown podzolic soil and a deeper, well developed 'A' horizon and, in the 'B' horizon, browner rather than redder colours. Using a Munsell colour book for soil colour determination, the colours are dominantly 10 YR or 7.5 YR and occasionally 5 YR. The brown podzolic soil has a blacker humus and a weakly developed 'A' horizon but most characteristically a redder 'B' horizon, mostly 5 YR or occasionally 2.5 YR. This red-brown ochreous horizon is termed a Bs horizon, that is a 'B' horizon dominated by sesquioxides. A sesquioxide is an oxide where the ratio of the element to the oxygen is 1:1½. The main one of concern is the red iron oxide, Fe₂O₃, but the aluminium oxide Al₂O₃ is also included in the sesquioxide group found in these soils.

While the changes from brown earth to brown podzolic are often subtle, it is evident that in Slapton Wood the brown podzolic soils tend to be more evident in the north-facing southern side of the wood, mostly on the slopes, with the redder colours tending to intensify on the mid-lower slope positions (Figure 1). Elsewhere profiles of the brown earth type are to be found. Soil profile descriptions are to be found in Tables 1 and 2.

Gley soils

Gley soils are found in the alluvial deposits in the valley bottom. Here, the soils are permanently waterlogged at depth and seasonally waterlogged towards the surface. Under waterlogged conditions, the soil is anaerobic and, being low in

Table 1. *Brown podzolic soil* (profile 1 on figure 1)Vegetation: *Castanea sativa*; *Quercus*—hybrid *petraea-robur*. *Luzula sylvatica*.

Horizon	cm	Description*
L	6–4	Litter of <i>Luzula sylvatica</i> , pH: 4.6
F	4–2	Black organic matter with fibrous roots, 5YR 2.5/1, pH: 4.2
H	2–0	Humus, occasional white quartz grains; fibrous roots. Black, 7.5YR N2/ Sharp boundary. pH: 4.2
A	0–4	5YR 3/4 dark reddish brown; mixed mineral-organic matter; common small-medium stones, many fine fibrous roots with decayed roots of <i>Luzula</i> . Moderately developed fine sub-angular blocky/fine-medium granular structure. pH: 3.8
B1s	4–50	5YR 5/8 yellowish red. Many small-medium stones, common woody, coarse roots. Moderately developed fine sub-angular blocky/fine-medium granular structures. Fine-medium macropores, 0.5% area, earthworm and decayed root holes. pH: 4.1
B2s	50–70	5YR 5/8. Abundant small-medium stones, few large stones; common coarse and common fine roots; weakly developed fine granular structure. Yellowish red. pH: 4.2
C	70+	5YR 5/6 yellowish red. Abundant small-medium stones, few large, platy and angular-subangular slate stones. Weakly developed fine granular structures; few fine-very fine woody roots. pH: 4.2

* Terms such as “common” and “small” or “fine” are defined precisely by Hodgson (1976); e.g.: small stones; (p. 25): 6 mm–2 cm, medium: 2–6 cm. Fine roots 1–2 mm diameter. Structure: (p. 31)—fine subangular blocky—<10 mm; fine-medium granular—<2 mm, 2–5 mm. Common coarse roots (p. 53)—2–5 per 100 cm². Common fine roots = 10–25 per 100 cm².

Table 2. *Brown earth*Vegetation: *Castanea sativa*; *Pinus sylvestris*

Horizon	Depth (cm)	Description
L	5–3	Litter of <i>Castanea</i> ; some <i>Pinus</i> needles. pH: 4.5
F	3–2	
H	2–0	Dark humus, 5YR 2.5/1, black. pH: 4.5
Ah	0–20	5YR 3/2 dark reddish brown weak, granular-subangular blocky, friable abundant small stones. pH: 4.2
AB	20–25	5YR 3/3 dark reddish brown weak, granular-subangular blocky, abundant small stones. pH: 4.3
B	26–65	5YR 5/7 yellowish weak granular-subangular blocky, abundant small-medium stones. pH: 4.4
C	65+	7.5YR 7/8 reddish yellow weathered angular slate with a soil matrix between. pH: 4.2

oxygen, the iron is present in the reduced (iron II) state, giving the soil a grey colour. Penetration of oxygen down soil pores, chiefly old root channels, transforms the iron to iron III, giving red, rusty mottlings in the soil. The oxygen may be in the soil air or dissolved in mobile soil water. Gley soil profiles, such as that shown in Table 3, give clear evidence of oxidation near the surface, with brown colours, and reduction at depth where near-stagnant water exists. Mottling occurs in the partially aerated zone between the two.

Iron II is much more soluble than iron III and thus the grey colour of lower, gley horizons may indicate that all the iron has been removed, in the reduced iron II state, in solution in mobile soil water. This leaves a pale, bleached, iron-free horizon at depth, difficult to distinguish from a gley horizon where the iron is present but in the reduced, pale-coloured form. The latter situation can, however, be identified by

Table 3. *Gley profile*

Vegetation: Ash (*Fraxinus excelsior*); Sycamore (*Acer pseudoplatanus*), Enchanters Nightshade (*Circaea lutetiana*), Hart's Tongue Fern (*Asplenium (Phyllites) scolopendrium*), Hemlock Water Dropwort (*Oenanthe crocata*).

Horizon	Depth (cm)	Description
L, F, H absent due to trampling and effects of winter flooding		
A(g)	0-15	5YR 4/4. Reddish brown, gritty silt loam; coarse subangular blocky-fine moderately developed structures: few fine fissures cracking to surface,* 2% mottles 5YR 4/6 yellowish red disposed along fissures. Firm consistence. pH: 5.6
B(g)	15-45	7.5YR 5/4. Brown silt loam; coarse subangular blocky, moderately developed structure; few fine pores, 0.1%; few medium/fine woody roots, some of a "shaving brush"† appearance. Moderately firm consistence. 5% mottles 5YR 4/6. Yellowish red. pH: 6.1
C1g	45-55	10YR 6/2. Light brownish grey, silty clay/silt loam. Weak consistence. Fine pores, iron stained 10%. 15-20% mottles, 5YR 4/6 yellowish red. Weak medium subangular blocky structure. pH: 5.6.
C2g	55-60	Unmottled blue-grey silty clay, 5Y 5/1 grey. pH: 5.2
C3	60+	Gravel, small platy particles. 7 cm—standing water.

* Profile surveyed in July, cracking to surface is absent or less marked in winter.

† Characteristics of root growth in summer and die back during waterlogging, giving tufted appearance to root mat.

taking a sample block of grey-coloured soil and leaving it in the air for a few days. The surface then takes on a darker colour than the interior of the soil block, indicating that the oxidation of iron has occurred on the soil block surface (the surface is unlikely to go red in a short space of time, merely darker). Observation suggests that this is the case with the Slapton gley soils: iron is present and in the iron II form at depth, rather than having been lost in solution.

DISCUSSION

Two factors are thought to contribute to soil differentiation in the wood: aspect and land use history. The brown podzolic soil is commonest on the cooler, moister north facing slopes, often where the Wood Rush *Luzula sylvatica* is present (Brookes and Burns, 1969, p. 135-6; Burton and Mercer, 1978, p. 699). Here, the cooler, moister conditions will tend to encourage the accumulation of acid organic matter, the acidity of the organic matter encouraging leaching. On the warmer, south, east and west facing slopes, the soils tend to be less red and 'A' horizons more prominent. The apparent correlation of soil type with aspect should, however, be treated with some caution.

It should be emphasised that interpretation of soil characteristics in terms of natural processes is not always possible. Britain has very much a man-made landscape and Slapton Wood is no exception. Study of old maps reveals that the north side of Slapton Wood (Loworthy Brake, Figure 1) is, in fact, a plantation on what was an old field system. The plantation is chiefly of Sweet Chestnut (*Castanea sativa*). Thus, the well developed 'A' horizon on the south facing slopes could be interpreted in terms of previous cultivation and homogenisation of the upper soil profile as much as it could be in terms of aspect. However, the redder Bs horizon is largely absent on the north side of the wood, indicating that the profile should be interpreted in terms of land use history superimposed on a pattern resulting from natural processes. On the north facing, south side of the wood there is no evidence for any previous field system. In addition there is a ground flora of plants which are slow to colonise and which would not be common if the ground had been recently

cultivated; these plants include the Bluebell (*Endymion (Scilla) non-scripta*), Wood Anemone (*Anemone nemorosa*) and Butcher's Broom (*Ruscus aculeatus*). These suggest that woodland has existed on the site for a long time. Oak (*Quercus* hybrid *petraea-robur*) and Beech (*Fagus sylvatica*) also occur but planted Sweet Chestnut is dominant here and it is clear that some disturbance of the site must have taken place during planting. It is therefore possible that the lack of an 'A' horizon in the north facing slopes could be interpreted in terms of truncation of the soil profile due to disturbance and erosion on the slope. There is, however, no clear evidence for this. Certainly, woodland has occupied the site for some time since the name "Wood Lane" for the track leading from the Field Centre to the wood occurs in Domesday times.

The origins of the soil profiles visible at the present day are thus open to discussion and it is difficult to separate the different possible and probable natural and man-made influences upon the soil types.

Comparison of the woodland soils with the soils in the agricultural areas around the woodland often reveals a less red profile, commonly 7.5 YR with some 10 YR to the north and west of the wood. Here cultivation has tended to homogenise the soils, mixing the organic matter with the mineral matter. Additionally, redder soils occur to the south of the wood, apparently associated with the more weatherable and redder Meadfoot slates and also, around Slapton village, with a deposit of Permian breccia. This is a Triassic deposit, itself of a strong red colour. It is also possible that slope top sites may be paler and more leached than slope foot sites, being present on older land surfaces than those of the incised valleys.

Comparison of soils from one area with those of another is not easy unless detailed cross-checking is carried out, but in mapping the Exeter district north of the Slapton site, Clayden (1971) records two soil series similar to those already described. These are the Dartington series (now termed the Manod series) a brown podzolic soil with a well developed Bs horizon, and discrete, dark humus when under woodland, and the Highweek series (now termed the Denbigh series), a brown earth on slate. Both these series are extremely widespread on the Devonian slates and it is probable that the soils of Slapton Wood could be included in these categories, as appropriate.

Glossary

For further explanations see:

Burnham (1980)—soil types.

Courtney & Trudgill (1976)—soil properties and processes.

Hodgson (1976)—Soil Survey handbook.

'A' horizon—an 'A' horizon is a mixed mineral—organic horizon.

'B' horizon—an altered mineral horizon.

Bs horizon—a B horizon dominated by sesquioxides (e.g. Fe_2O_3 ; Al_2O_3 ; that is 1 Fe to $1\frac{1}{2}$ O or 1 Al to $1\frac{1}{2}$ O).

Brown earth—loamy soils with a brown or reddish, friable, non-calcareous sub-surface horizon, with no marked differentiation except A and B horizons.

Brown podzolic soil—transitional between a brown earth and a podzol, where a Bs horizon is present, dark humus, some evidence of bleaching but no strong Ea.

Ea horizon—albic (white/pale) eluvial horizon.

Eluvial horizon—one from which considerable losses of soluble material, especially iron, have occurred.

F—Fermentation layer: plant remains partially recognisable.

H—Humus layer: plant remains unrecognisable.

L—Litter layer: plant remains recognisable.

Munsell Colour—scheme for colour description with numbers for Hue, value and chroma: *hue* is the dominant spectral colour, *value* lightness/darkness; *chroma* colour saturation, reported: Hue (e.g. 5 Y), value/chroma (e.g. 4/4). See Courtney & Trudgill (1976) p. 91 for a fuller explanation.

pH—acidity or alkalinity; negative logarithm₁₀ of the hydrogen ion concentration.

pH < 7 = acid, > 7 = alkaline. See p. 29–31 of Courtney & Trudgill (1976).

Poaching—dimpling and compaction of the surface by cattle trampling.

Podzol—possesses a dark H layer and a marked Ea horizon.

Soil series—a group of similar soil profiles formed under similar environmental conditions on similar parent material.

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