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SOILS AND LAND USE ON CHALKY BOULDER CLAY

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Introduction

Chalky Boulder Clay is a widespread deposit in central and eastern England, and is probably the most commonly encountered soil parent material in the area. It is a clayey, mainly unstratified deposit, containing chalk and other calcareous materials. Stones are ubiquitous throughout the deposit but commonly account for less than 10 per cent of its volume. On geological drift maps Chalky Boulder Clay is not systematically distinguished from other boulder clays, but occasionally additional lettering is engraved on the map. In general the term Chalky Boulder Clay is confined to tills containing chalk and flint, in a matrix derived from Jurassic or Cretaceous clays.

Local facies of Chalky Boulder Clay have been described and named by a number of workers concerned with the chronology of glacial deposits.[1] The Chalky Boulder Clay is considered to have been laid down during the penultimate (Saale) glaciation, but similar deposits of greater age are locally important. To the soil scientist the lithology and the amount of calcareous material in the tills are of fundamental importance. The age of a till is only important where it occurs on stable land surfaces exposed to weathering processes since deposition, where it forms the parent material of contemporary soils. Age is less important where the till is wholly or partly obscured by later drift, or only recently exposed by denudation. It is to be expected that the classification of soils developed on boulder clay will show only limited correlation with distinctions proposed in the field of Pleistocene geology. The soil scientist also frequently wishes to distinguish soil parent materials according to physical or chemical properties which are not necessarily related to Pleistocene chronology.

Isolation of the time factor in soil formation is usually even more difficult than the dating of Pleistocene deposits generally. However, the main occurrences of Chalky Boulder Clays, forming parent material of contemporary soils, are those of Saale age. They occupy low dissected plateaux in the Midlands and East Anglia. Most of these surfaces appear to have been reasonably stable during the succeeding (Eemian) interglacial. Solifluction effects related to the later Weichsel cold period are evident in many soil profiles, but on level sites, actual loss of surface material by this process was probably not great.

Soils

The Chalky Boulder Clay areas may be divided into two main soil associations, a Midland association occurring in Leicestershire, Northamptonshire, South Nottinghamshire and Kesteven, and an Eastern association in Essex, Cambridgeshire, Suffolk and Hertfordshire. Between the two associations there is a broad boundary zone in Bedfordshire, Buckinghamshire and Huntingdonshire. The dominant soils of the Eastern association are the Hanslope and Stretham series.[2] Hanslope soils are found extensively on plateau and interfluve sites. They are fine textured gleyed calcareous soils with imperfect drainage status. The plough layer consists of a stiff clay loam or clay and overlies a yellowish brown or olive brown clay with faint greyish and ochreous mottles, which becomes greyer and more calcareous with depth. Stretham soils are similar in texture but better drained. They occupy valley sides where run-off may be expected to be greater, and also occur at sites where a thin layer of Chalky Boulder Clay overlies chalk or gravel. The immediate subsoil is brown or reddish brown, over yellowish brown chalky clay.

Both soils form good heavy arable land and normally have a well developed structure in the plough layer, though this may degenerate due to untimely cultivations. Strong cracking in summer develops a markedly blocky structure in the immediate subsoil which merges to massive till at one to one-and-a-half metres. Maintenance of good structural conditions is essential to the optimum use of the Hanslope soils and this has been achieved, in part, by regular mole drainage, which is a traditional method of drainage in the Eastern Counties. The effectiveness of moling for this purpose, and for drainage, is probably related to the presence of large amounts of calcium carbonate (Table 1) associated with a natural tendency to form stable structural aggregates. In Stretham soils natural drainage conditions are reasonably good and few, if any, remedial measures are needed.

Table 1

Percentage clay and calcium carbonate content of selected profiles
Eastern association

Depth, cm	SOIL SERIES ..	*Hanslope*				*Stretham*		
	PROFILE NO. ..	*1*	*2*	*3*	*4*	*5*	*6*	*7*
5–17	Percentage $<2\mu$ clay	31	35	45	43	27	39	32
	Percentage $CaCO_3$ ..	1.4	4	5	4	1.7	27	2.4
25–42	Percentage $<2\mu$ clay	54	54	51	47	50	42	43
	Percentage $CaCO_3$ ..	1.5	25	3	5	0.8	28	34
50–62	Percentage $<2\mu$ clay	48	47	52	45	51	34	
	Percentage $CaCO_3$ ..	38	40	46	34	37	49	
75–90	Percentage $<2\mu$ clay	49	44	55		54	35	45
	Percentage $CaCO_3$ ..	47	52	46		42	57	39

Midland association

Depth, cm	SOIL SERIES ..	*Ragdale*				*Hanslope*		
	PROFILE NO. ..	*8*	*9*	*10*	*11*	*12*	*13*	*14*
5–13	Percentage $<2\mu$ clay	42	44	35	44	42	39	45
	Percentage $CaCO_3$ ..	0	0	0	0	0.2	0.3	10
27–42	Percentage $<2\mu$ clay	43	52	56	53	39	48	
	Percentage $CaCO_3$ ..	0	0	0	0	14	17	
50–62	Percentage $<2\mu$ clay	50	49	53	49		43	40
	Percentage $CaCO_3$ ..	7	15	21	0.3		30	39
75–90	Percentage $<2\mu$ clay	43	43	46	41	41	46	43
	Percentage $CaCO_3$ ..	27	20	21	19	26	30	40

The Hanslope series occurs also in the Midland association (Figure 1), where it is found on landscape facets similar to those of the Stretham series in the Eastern association. Level and gently sloping plateau sites have poorly drained surface-water gley soils of the Ragdale series.[3] They have a clay loam or clay plough layer overlying prominently mottled clay in which the faces of the structural aggregates are mainly grey and the interiors of the peds contain frequent ochreous mottles. Predominantly grey calcareous clay is found at depths below 45 centimetres and always within 76 centimetres. The lower solum contains sporadic, small, semi-spherical sandy pockets which are absent in the deeper till. These are commonly regarded as evidence of solifluction processes since the till was laid down.

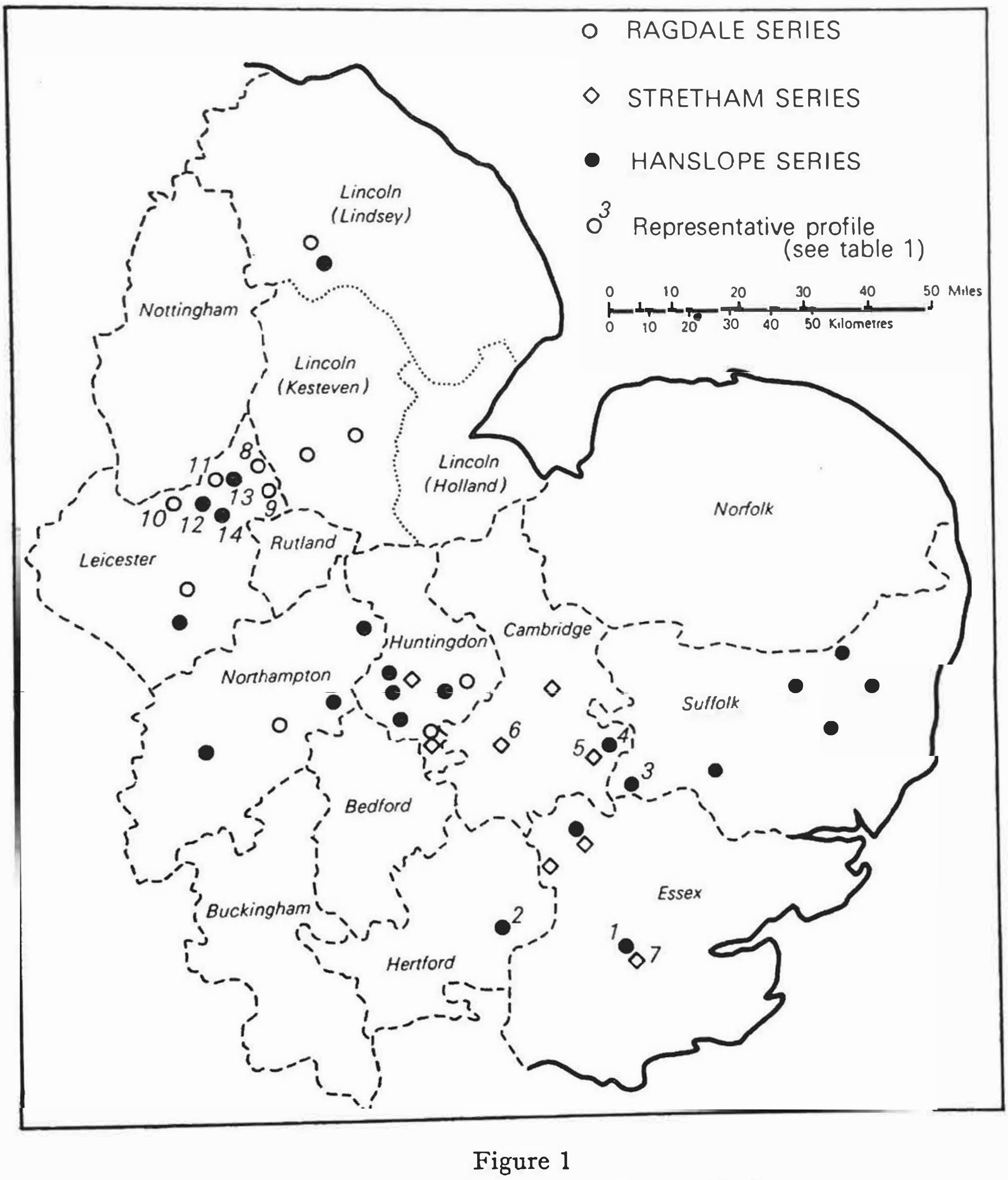

Figure 1
Soil distribution (representative profiles)

The upper horizons of Ragdale soils are acid under natural conditions and the profile is a product of gleying and decalcification followed by a relative accumulation of clay in the B horizon (Table 1). There is, however, little field evidence of clay illuviation. Under old pasture the structure of the surface horizon is often fine and well developed but this deteriorates rapidly in arable use and the soil becomes almost intractable when wet. The clay-enriched, coarsely structured subsoil horizon impedes water movement and the prominent mottling indicates poor drainage. Structure is at best moderately developed in the subsoil and becomes massive with depth as the soil merges into the grey chalky parent material.

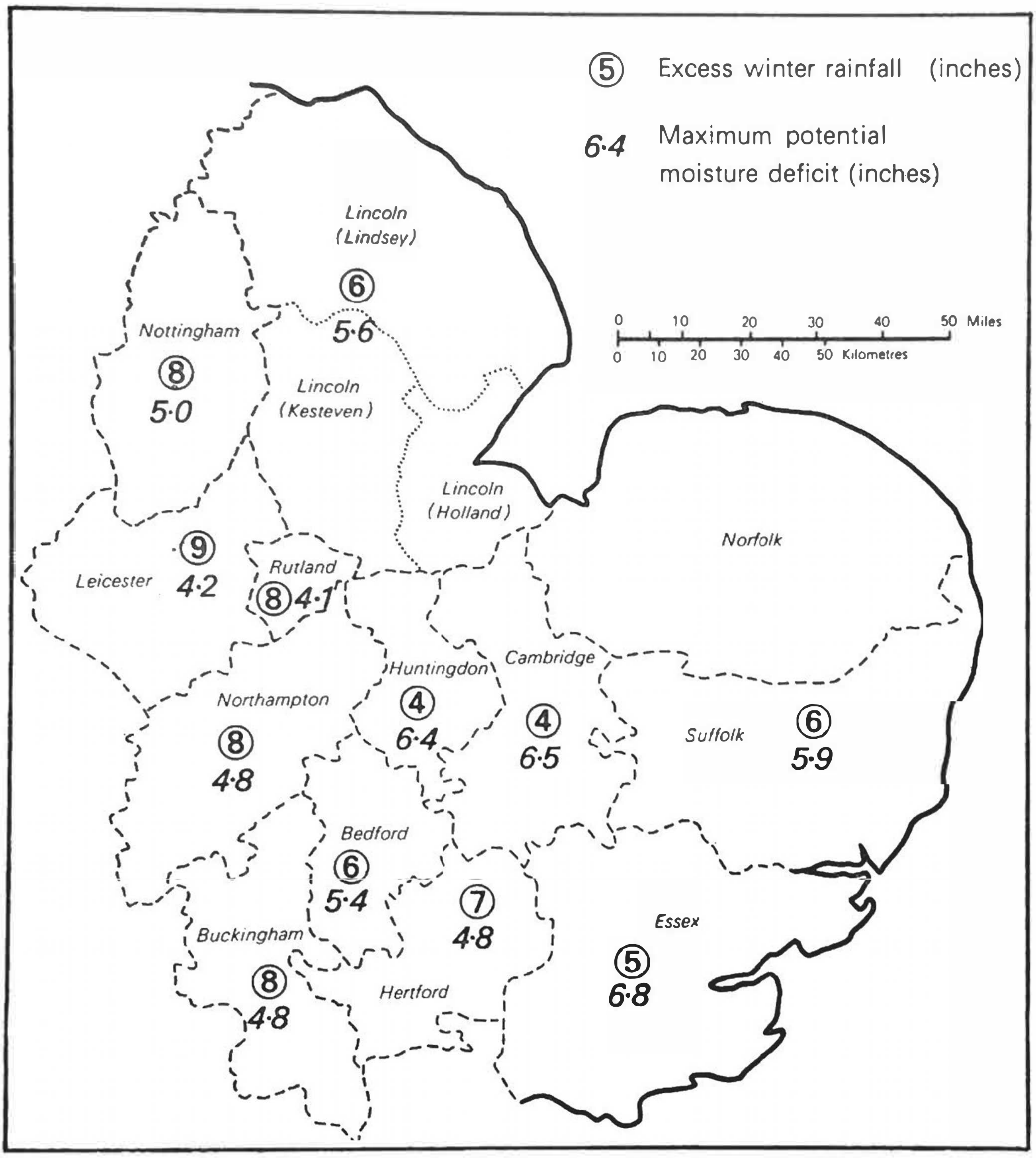

Figure 2

Rainfall and potential moisture deficit

Source: Potential transpiration, *Technical Bulletin* 16, Ministry of Agriculture, Fisheries and Food, H.M.S.O. (1967).

It is believed that the differences in the soils of the two associations are mainly due to two factors. The differences in composition of the till in the two areas and to slight climatic differences. The Eastern till contains up to twice as much carbonate as the Western till (Table 1) and the area has less water available for leaching due to lower average winter rainfall and a higher summer moisture deficit (Figure 2). It would, therefore, take much longer for the carbonate in the Eastern till to be completely leached from the profile. Interpretation of the climatic factors is dependent on the climates of the two areas having retained a similar relationship since the end of the glacial periods.

Evidence of the solifluction effects in the top 60 centimetres of the Ragdale soils indicates that the soils of the plateau sites developed to some extent during the last interglacial period. During the last glacial period material was removed from the sloping sites by solifluction processes so that at the end of this period soil development on the slopes would start afresh with 'new' parent material, whereas pedogenesis on the flatter sites would be operating on already partly altered material. Differences between soils on slopes and those on the plateaux, starting with parent materials at different weathering stages, would be accentuated by the smaller amounts of water available for soil-forming processes due to extra run-off on sloping sites.

Land Use

The extent to which land use and type of farming is influenced by physical factors such as soil or climate varies with economic and social conditions, many beyond the control of the individual farmer. However, skilful husbandry may allow a farmer to overcome the limitations of his land, and pursue policies which his neighbours find impracticable. In considering regional systems of land use the effects of individual farmers are largely masked, and the final pattern is largely dependent upon soil, climate, relief, and an element of tradition, which includes both historical trends, and the tendency of individuals to meet similar problems in similar ways by gaining from the experience of each other.

In the Middle Ages the farming systems of the two soil associations were similar in that the end products of the two areas were grain, beans and lean stock. The differences were in social organisation. The open-field system was well established in the Midlands but unimportant in East Anglia. The change to amalgamated holdings came in the Midlands with the advent of the enclosure movement. During the fourteenth and fifteenth centuries this movement caused the abandonment of many villages, and the more complete enclosure movements of the late eighteenth and early nineteenth centuries left very few open fields remaining. The rig and furrow micro-relief topography so characteristic of Chalky Boulder Clay areas of the Midlands, originally produced as an aid to drainage,[4] was allowed to acquire a turf of natural grasses.[5] The change to grazing in the fifteenth century was influenced by the high demand for wool. In the nineteenth century stock-farming was preferable because of its lower labour requirement in a period when agricultural wages in the Midlands were high.[6] The long history of open-field farming would, also, have left these wet, heavy lands in a very poor structural condition, on which extensive arable farming would have been difficult. Some reversion to arable farming occurred during the nineteenth century and by the 1870s 30 per cent of the area of many Midland parishes was in arable crops,[7] after which the arable acreage again declined. With a less favourable climate for grass production and better drained and structured soils the arable farming systems of the Eastern association continued. The end-product in the two areas—livestock—was similar, but in East Anglia stock were stall fed or folded onto arable forage crops, a system impossible in the Midlands because of the dangers of poaching. The importance of stock in the agriculture of the two areas continued well into the twentieth century. This can be seen from the grass acreage in the agricultural returns for the

East Midlands and the fact that in 1939 only 20 per cent of the arable produce was sold off the farms of Suffolk.[8] The arable acreage of both areas fell during the period 1870–1940 and it was only the war and the post-war system of agricultural support which reversed this process. The influence of the local soil pattern on the systems of agriculture is seen in the fact that the parishes of Sileby and Seagrave in Leicestershire, with predominantly Hanslope soils, had greater than 50 per cent of their area under arable cropping in the 1870s, and again in 1965 when, in general, the arable acreage of the East Midlands has regained the levels of the 1870s some parishes, for example Willoughby-on-the-Wolds, with predominantly Ragdale soils, still had greater than 90 per cent of their area under grass. As can be seen from the comparison of the agricultural returns of the two areas being considered (Table 2) the tradition of the Eastern association has continued to give this region a considerable lead in the production of arable crops.

Table 2

Percentage use of agricultural land

Crop	*Area*		
	Seven North Leicestershire parishes[1]	*North Essex*[2]	*West Cambridgeshire and Huntingdonshire*[2]
Permanent pasture ..	52	5	12
Temporary pasture ..	14	8.5	11
Arable ..	34	86.5	77
Total cultivated	48	95	88
Potatoes and sugar beet ..	1.6	9	9

[1]From M.A.F.F. Parish Returns (1965)

[2]From Cambridge University, *Farm. Econ. Br. Rep. No. 63* (1963)

Under the present system of agricultural support a continued increase in the acreage of arable crops is to be expected in the Midland association because of higher returns from arable farming, and also a lack of labour. While the difficulties of an arable system are greater in the Midland association improved drainage systems and farmers' skill are likely to reduce them to some extent. Whether a continuous arable system is possible is unknown as there are few farmers attempting this. Their experience would suggest that some sort of grass crop is needed to help restore the structure impaired by a succession of arable crops. Even on predominantly arable farms in this area the proportion of root crops is lower than in the Eastern association (Table 2). Efficient production of these crops requires better structural and drainage conditions than cereals. Such conditions are difficult to achieve on Ragdale soils.

Acknowledgments

The author acknowledges with thanks the helpful discussion provided by Mr. A. J. Thomasson.

NOTES

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[4] E. Kerridge, Ridge and furrow and agrarian history, *The Economic History Review* 4, 2nd series (1951) 16.

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[6] E. J. T. Collins and E. L. Jones, Sectoral advance in English agriculture, *The Agricultural History Review* 15 (1967) 2, 65.

[7] *Land Utilisation Survey—The Land of Britain, Part 57, Leicestershire* (ed. L. Dudley Stamp), Geographical Publications (London, 1943).

[8] *Land Utilisation Survey—The Land of Britain, Parts 72–73, Suffolk* (ed. L. Dudley Stamp), Geographical Publications (London, 1941).