



0000332070



09. NOV

47557

Reprinted from
The East Midland Geographer
Vol. 5, Pt. 6, No. 38
December 1972

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF NOTTINGHAM

631 .445.3(425.65)

BEA

PARTICLE SIZE DISTRIBUTION OF THE SURFACE SOIL ON THE LOWER GREENSAND IN EASTERN BEDFORDSHIRE

F. BEAVINGTON

Abstract

The soils of the Lower Greensand plateau in eastern Bedfordshire are coarse textured, deep, friable, low base status brown earths. A sample area of three square kilometres has been studied in detail and a map of surface soil texture produced. This property was found to vary through three types: sand, loamy sand, and sandy loam. All soils were dominated by the coarse sand fraction, which varies from 56 to 90 per cent; fine sand varies from 6 to 22 per cent, silt from 2 to 17 per cent, and clay from 2 to 13.5 per cent. Parent material sets the limits for these variations and together with glaciation and wind erosion has operated generally to affect the surface texture pattern, whilst marked local effects have been produced by stream action, rainwash on slopes and past marling.

INTRODUCTION

Single property soil maps are comparatively uncommon and only a few are of texture. Kay's map of part of south Hampshire is an example of one of these, though in this case texture type boundaries are superimposed on series.¹ A study has been carried out of the soils of the Lower Greensand plateau of eastern Bedfordshire. The texture of their surface horizons has been mapped for a representative area of about three square kilometres of the western part of the plateau in the parish of Sandy.² It was found that this material varied through three texture types. This paper describes these soils and in particular discusses the surface texture distribution and the causes in its variation.

The Lower Greensand outcrops in eastern Bedfordshire and the bordering parts of Cambridgeshire and Huntingdonshire to form a low but steep-sided plateau 60 metres O.D. and three to four kilometres wide between the Oxford Clay and the Gault Clay. The formation emerges from a boulder clay cover at Waresley and extends for eight kilometres south-westwards to Sandy where it ends abruptly in a river cliff formed by the transverse River Ivel. Apart from minor undulations and a small stream at Potton the surface of the plateau is featureless and waterless. A section of the formation at Sandy shows that the material is current bedded with irregularly distributed fine streaks of clay as described in the Sandringham Sands.³ The material is weakly cemented except where iron-rich solutions produced a secondary cementation, forming hard, ferruginous masses of carstone. Annual mean rainfall on the Greensand in eastern Bedfordshire is 57 centimetres. A summary of the agricultural development of the area is given by Beavington.⁴

METHODS OF STUDY

The particle size definitions are according to the International Classification (coarse sand 0.2 to 2 millimetres, fine sand 0.02 to 0.2 millimetres, silt 0.002 to 0.02 millimetres, clay under 0.002 millimetres). The textural types, and the terms 'variant' and 'phase', are those defined in the *Field Handbook* of the Soil Survey of Great Britain.⁵ For the purpose of surface texture the layer 0 to 20 centimetres is considered. The soil

survey was carried out by means of soil-pit inspection, field assessment, and 110 mechanical analyses (0 to 20 centimetres), the texture type boundaries being determined by this work. Mechanical analysis was based on the method of Bouyoucos.⁶

SOIL DESCRIPTION

Early work on these soils was carried out by Rigg, who divided them into 'dark sands' and 'brown sands', though the distinction is not clear in the field today.⁷ Recently, King, in a reconnaissance survey of the soils of the one-inch Ordnance Survey sheet 146,⁸ classifies the soils on the Lower Greensand at Sandy, and over much of this formation in Bedfordshire, as brown earths of low-base status. They are designated Cottenham Association, after the series named by Hodge and Seale on the Lower Greensand around Cottenham and on the Haddenham Ridge, in Cambridgeshire.⁹ No analytical data are included for these soils in the Sandy area.

The surface horizons of the soils developed on the Lower Greensand in eastern Bedfordshire were found to be friable, weakly structured, generally dark greyish-brown sands, loamy sands and sandy loams, overlying deep, brown sub-soils of loamy sand to sandy loam. Carstone fragments (over two centimetres) occur in most profiles and vary considerably in amount and size from place to place. Frequently they are rough slabs up to about 15 centimetres long, though some are much larger, and boulders of one metre are found occasionally. All soils are leached, acid and highly permeable, draining to a water table at considerable depth. Profile 1 is typical of cultivated soil.

PROFILE 1		
Ap	0 to 25 centimetres	Dark greyish brown friable coarse loamy sand with some bleached sand grains and a few small carstone fragments, very weak crumb structure; clear boundary
(B)	25 to 73 centimetres	Brown friable loamy sand containing small carstone fragments; very weak sub-angular blocky structure; a few fine roots; occasional worm channels; grading to strong brown loamy sand, weakly cemented

Apart from bleached sand grains, there is little evidence of podzolisation, even under old conifer or heath. In a few places, however, in both communities there is a weakly bleached layer under the litter and top mineral horizons, but there is no visual evidence of iron illuviation beneath.¹⁰ Profile 2 is typical of a heathland site at Sandy.

PROFILE 2		
L		Litter, mainly <i>Erica vulgaris</i> up to 1 centimetre thick
F/H		Very dark grey mor humus with some bleached sand grains, up to 1 centimetre thick
A	0 to 15 centimetres	Dark grey structureless sand with numerous bleached grains; many fibrous roots; no earthworms; merging boundary
B	15 to 75 centimetres+	Strong brown sand, weakly cemented in lower profile; fragments of carstone

Particle size distribution of the surface soil in eastern Bedfordshire

Further variations characterise these soils. A variant with much broken carstone, so that surface and sub-soil are impenetrable to the auger, occurs widely over Sandy Heath. There was evidence that this material seriously impeded root development of small trees planted in one of these areas.¹¹ Another variant, a deep sand with very few carstone fragments, occurs in places. Two distinctive phases occur on the slopes bounding the Greensand: a yellowish-brown truncated soil is found on the steep eroding upper slopes, whilst a deep A horizon occurs at the base of these slopes. Both phases are considered below in relation to textural differences. Finally, a brown loamy sand to sandy loam containing gravel and small stones of non-carstone material occurs over an area of 0.2 square kilometres on Sandy Heath (Figure 2; 205492). This layer overlies normal sub-soil material.

SURFACE TEXTURE

Mechanical analysis results of the 110 samples are summarised in Table I. The mean of 91 samples from cultivated land and the mean of 19 samples from uncultivated land are shown, whilst an example from the sandiest soils and another from the least-sandy soils show a range of texture through three types: sand, loamy sand and sandy loam. Coarse sand dominates all soils and ranges from 56 to 90 per cent. Fine sand ranges from six to 22 per cent, silt from two to 17 per cent, and clay from two to 13.5 per cent. Invariably, as the soils become sandier they also become more and more dominated by coarse sand, with less clay and silt, and less fine sand also. Moisture content is very low and varies with clay content. Soils with over eight per cent clay averaged 1.4 per cent moisture, whilst soils with under five per cent clay averaged 0.9 per cent moisture; mean moisture content for all samples is 1.1 per cent.

TABLE I

Texture, moisture and acidity of all samples and for the two extreme ends of the range

Sample	Coarse sand per cent	Fine sand per cent	Silt per cent	Clay per cent	Moisture per cent	pH
Cultivated (mean)	69.5 (±6.2)	14.7 (±3.9)	9.8 (±2.8)	6.2 (±2.1)	1.1	6.2
Uncultivated (mean)	76.5 (±4.6)	11.3 (±2.7)	7.6 (±2.9)	4.7 (±1.5)	1.1	4.5
Extremes, sample no.						
116	90.1	6.2	1.5	2.2	0.8	4.25
170	61.5	11.5	14.0	13.5	1.6	5.5

Figure 1 illustrates the particle size distribution of the 110 samples in relation to the three texture types with loamy sand the major one. Figure 2 shows the texture distribution for the area of detailed survey, together with the clay and total sand percentages of the samples recorded at the sites where they were taken. Loamy sand occupies 78 per cent of the surface, sand 17 per cent, and sandy loam five per cent.

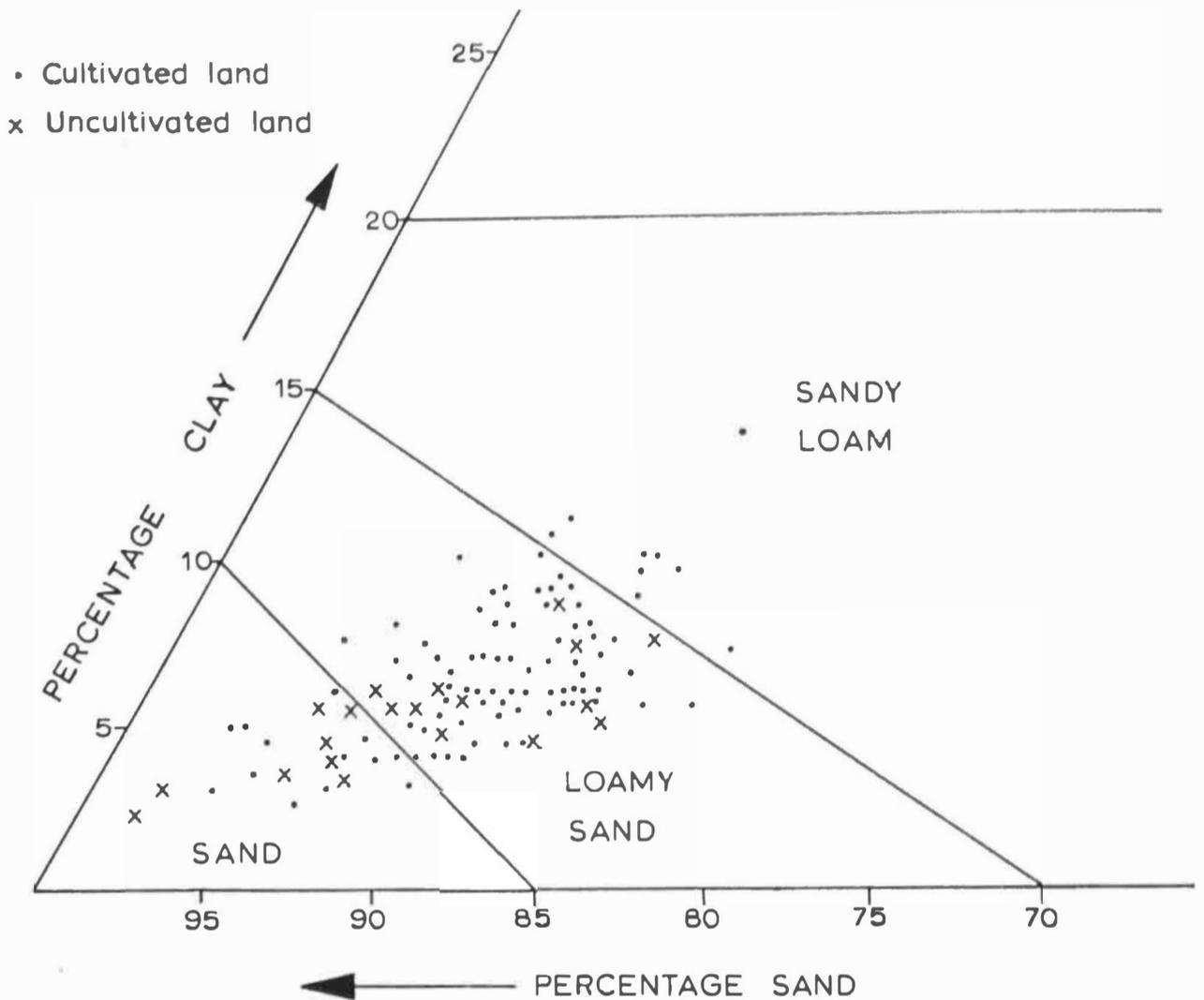


FIGURE 1

Particle size distribution of 110 samples shown on part of the Whitney Diagram

Six factors contribute to the variations in surface texture: parent material, glaciation, stream action, rainwash on slopes, wind erosion and marling.

A quarry exposure in the Lower Greensand reveals the fine streaks of clay in varying concentrations, and also the presence of clay particles between the sand grains. Two samples taken randomly from the quarry face, three to six metres below the surface, had clay contents of 4.5 and 7.0 per cent, whilst a third sample, from which clay streaks were excluded, had only 3.0 per cent clay. Exposures also show the irregular masses of carstone. Thus some of the variation in the distribution of clay in the surface soil, and the uneven distribution of the carstone fragments, are related to the parent material.

Glaciation may have left a legacy on this area. In places the surface soil contains more clay than was found in the parent material. The area with gravel and small stones (under five centimetres in diameter) at the surface (Figure 2; 205492) has an average clay content of 8.9 per cent (± 1.11). A number of these stones were identified as Triassic and Jurassic material, which could be derived either from the Lower Greensand or from boulder clay. Heavy mineral analysis of samples from the parent material in the quarry and from three variants of surface soil, including

Particle size distribution of the surface soil in eastern Bedfordshire

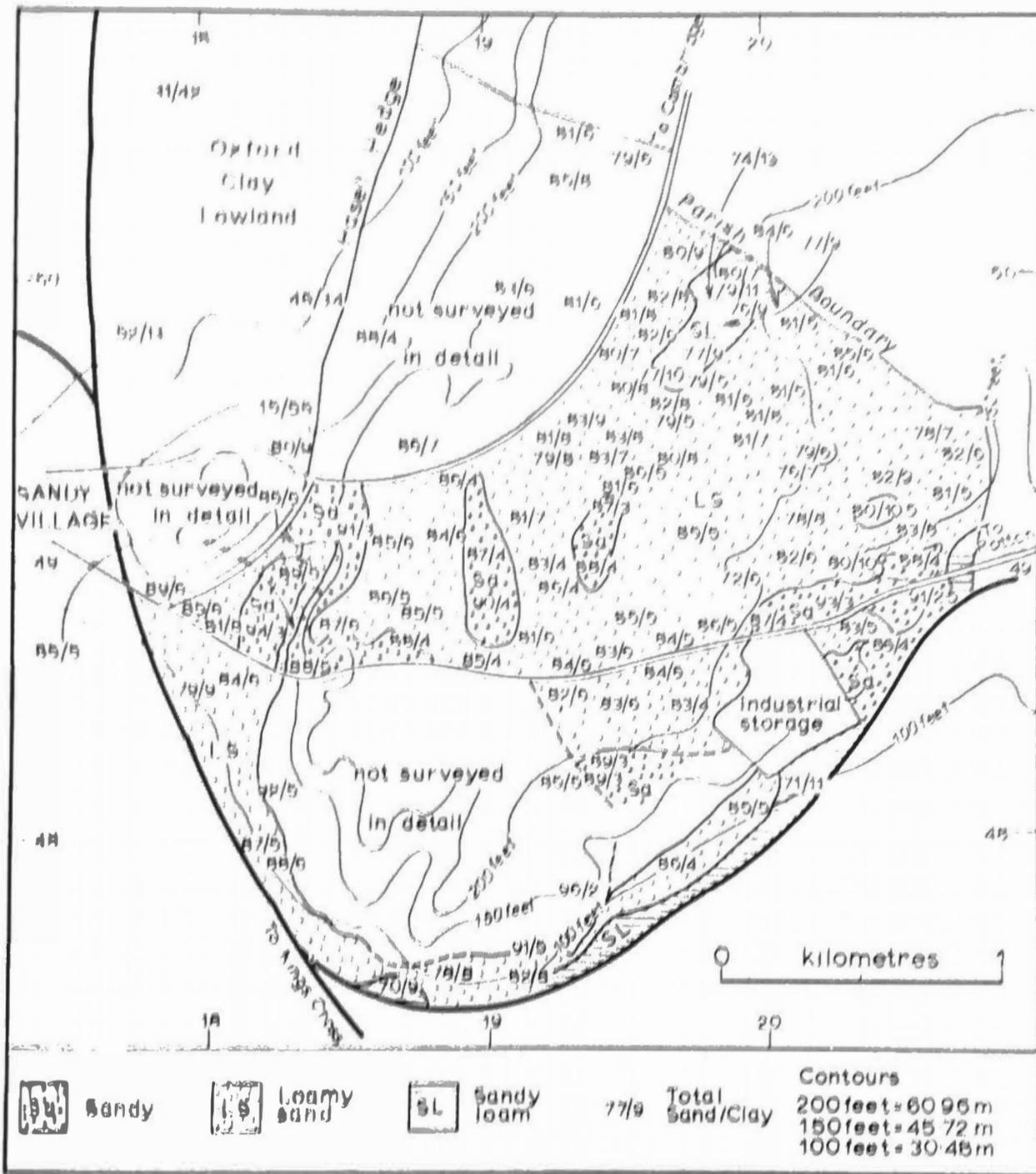


FIGURE 2

Surface texture distribution for a sample area of the Lower Greensand at Sandy (total sand and clay fractions are shown for each sample at the site where taken)

the material containing Triassic and Jurassic fragments, showed some variation in concentration, particularly in respect of the parent material and surface soil samples (Table II). However, the heavy mineral assemblages are similar, with abundant staurolite and kyanite, and small amounts of zircon, brookite and others, indicating that the material was derived from the Lower Greensand, and that no appreciable amounts of glacial drift are present; moreover, there are no distinctive minerals that could not have been derived from the Lower Greensand. It is likely that the whole plateau had a boulder clay deposit, but this is now removed. The material with the Triassic and Jurassic fragments, and more clay, is probably a wash deposit produced at the end of the glacial period, and may contain small amounts of sand and clay from boulder clay, as well as some erratic stones and gravel.

TABLE II
Heavy mineral concentrations in soils and parent materials

<i>Sample</i>	<i>Soil</i>	<i>Depth of sampling</i>	<i>Number of heavy minerals (per 10 grammes of soil)</i>
1M	Sandy loam with gravel and small stones (non-carstone)	0 to 20 centimetres	12
2M	Parent material	5 metres	2
3M	Loamy sand with much broken carstone	0 to 20 centimetres	16
4M	Deep sand	0 to 20 centimetres	11

Surface water is absent from the plateau, but there is one well-developed dry valley (Figure 2; 180488). Soil from the floor of this valley (sample 92) showed a marked decrease in coarse sand and increases in fine sand and silt, compared with the average values for the Greensand plateau (Table III). However, the effects of former streams in assorting material on their valley floors is difficult to separate from the effects of rainwash and other processes, considered below.

Rainwash and gravity processes have produced a continuous texture gradient on the slopes of the plateau, so that downslope the sand fractions become progressively smaller and the silt and clay higher, to the extent shown by the data for two slopes in Table IV. The distance from top to bottom of these slopes is about 250 metres.

TABLE III
Soil texture in valley floor
(values in percentages)

<i>Sample</i>	<i>Coarse sand</i>	<i>Fine sand</i>	<i>Silt</i>	<i>Clay</i>
92	46.0	26.4	21.3	6.0
Mean values of all samples ..	69.5	14.7	9.8	6.2

TABLE IV
Texture differences between top and bottom of slopes
(values in percentages)

<i>Sample</i>	<i>Coarse sand</i>	<i>Fine sand</i>	<i>Silt</i>	<i>Clay</i>
Slope A 110 top ..	84.6	7.3	5.5	3.0
111 bottom ..	65.7	15.5	8.5	9.0
Slope B 20 top ..	81.6	10.6	4.0	5.0
117 bottom ..	76.2	11.8	6.5	6.5

East Midland Geographer

TABLE II
Heavy mineral concentrations in soils and parent materials

<i>Sample</i>	<i>Soil</i>	<i>Depth of sampling</i>	<i>Number of heavy minerals (per 10 grammes of soil)</i>
1M	Sandy loam with gravel and small stones (non-carstone)	0 to 20 centimetres	12
2M	Parent material	5 metres	2
3M	Loamy sand with much broken carstone	0 to 20 centimetres	16
4M	Deep sand	0 to 20 centimetres	11

Surface water is absent from the plateau, but there is one well-developed dry valley (Figure 2; 180488). Soil from the floor of this valley (sample 92) showed a marked decrease in coarse sand and increases in fine sand and silt, compared with the average values for the Greensand plateau (Table III). However, the effects of former streams in assorting material on their valley floors is difficult to separate from the effects of rainwash and other processes, considered below.

Rainwash and gravity processes have produced a continuous texture gradient on the slopes of the plateau, so that downslope the sand fractions become progressively smaller and the silt and clay higher, to the extent shown by the data for two slopes in Table IV. The distance from top to bottom of these slopes is about 250 metres.

TABLE III
Soil texture in valley floor
(values in percentages)

<i>Sample</i>	<i>Coarse sand</i>	<i>Fine sand</i>	<i>Silt</i>	<i>Clay</i>
92	46.0	26.4	21.3	6.0
Mean values of all samples ..	69.5	14.7	9.8	6.2

TABLE IV
Texture differences between top and bottom of slopes
(values in percentages)

<i>Sample</i>	<i>Coarse sand</i>	<i>Fine sand</i>	<i>Silt</i>	<i>Clay</i>
Slope A 110 top ..	84.6	7.3	5.5	3.0
111 bottom ..	65.7	15.5	8.5	9.0
Slope B 20 top ..	81.6	10.6	4.0	5.0
117 bottom ..	76.2	11.8	6.5	6.5

Particle size distribution of the surface soil in eastern Bedfordshire

Silt and clay fractions are particularly low on the upper, eroding sections of slopes (Table IV). There is, however, no evidence to suggest that cultivation operations accelerate these processes (Table V).

TABLE V
Mean texture values for upper slopes
(values in percentages)

	<i>Coarse sand</i>	<i>Fine sand</i>	<i>Silt</i>	<i>Clay</i>
Cultivated ..	83.4 (± 1.3)	8.57 (± 1.4)	4.5 (± 0.7)	4.4 (± 0.8)
Uncultivated ..	83.5 (± 4.5)	8.02 (± 1.5)	4.7 (± 2.3)	3.8 (± 1.4)

Often in spring clouds of soil particles are carried across the plateau and sand spirals are formed. The much larger number of heavy minerals found in the surface soil than in the parent rock sample in the quarry might be investigated further in relation to the effects of wind erosion.

Soil in the sandy loam class, with clay contents as high as 13.5 per cent, was found in two fields near the Oxford Clay lowland (Figure 2; 198498). Corroborated evidence shows that at least one of these fields had received cart-loads of clay in the 1870s.¹² In Table VI samples 48, 155 and 170 are from the marled land, whilst sample 49 is from adjacent land, which was unmarled because it was under conifer plantation in the latter half of the 19th century. Thus after about 100 years, much of this added clay is still present in the surface soil.

TABLE VI
Texture of marled land
(values in percentages)

<i>Sample</i>	<i>Coarse sand</i>	<i>Fine sand</i>	<i>Silt</i>	<i>Clay</i>
48 ..	63.6	15.7	10.5	11.0
155 ..	62.2	14.5	14.0	9.5
170 ..	61.6	11.5	14.0	15.5
49 (unmarled)	67.0	17.2	10.0	6.0

The parent rock broadly sets the limits of surface soil texture in this area. Stream action, rainwash and marling have had strictly localised, but easily demonstrable, effects. Wind, glacial activity and parent material have operated generally, and the extent of their effects is more difficult to assess. It seems, however, that combinations of these six factors would largely explain variations in the texture of the surface horizons, not only on the Lower Greensand widely, but over other sand lands also.

NOTES

- ¹ F. F. KAY, *A soil survey of the strawberry district of south Hampshire* (University of Reading Department of Agricultural Chemistry, 1939).
- ² F. BEAVINGTON, *Market gardening in central and eastern Bedfordshire, Unpublished Ph.D. thesis* (University of London, 1961), where full details of analytical methods and analytical results may be found.
- ³ C. P. CHATWIN, *British Regional Geology: East Anglia and adjoining areas*, 4th edition (H.M.S.O., 1961).



East Midland Geographer

- ⁴ F. BEAVINGTON, The trend to more extensive market gardening in Bedfordshire, *Trans. Inst. Br. Geogr.* 33 (1963) 89–100.
- ⁵ SOIL SURVEY STAFF, *Field Handbook* (Soil Survey of Great Britain).
- ⁶ G. J. BOUYOUCOS, A recalibration of the Bouyoucos hydrometer method for the mechanical analysis of soils, *Agron. J.* 43 (1951) 434–438.
- ⁷ T. RIGG, The soils and crops of the market garden district of Biggleswade, *J. Agric. Sci.* 7 (1916) 385–431.
- ⁸ D. W. KING, *Soils of the Luton and Bedford district, a reconnaissance survey*, Special Survey No. 1 of the Soil Survey of England and Wales (1969). King defines silt and fine sand according to the American classification of particle size, but since coarse sand dominates the Lower Greensand material, texture classes from both classifications are deemed to be approximately comparable as far as these soils are concerned.
- ⁹ C. A. H. HODGE and R. S. SEALE, The soils of the district around Cambridge, *Mem. Soil Surv. Gt Br.* (1966).
- ¹⁰ Podzolisation is better developed on the Lower Greensand at a higher altitude and under a higher mean rainfall at Woburn on the Bedfordshire–Buckinghamshire border.
- ¹¹ F. BEAVINGTON and S. V. ADU, Studies on the effects of restricted rooting depth on the production of grass and Scots pine, *Can. J. Soil Sci.* 51, no. 1 (1971) 127–128.
- ¹² F. BEAVINGTON, *op. cit.* (1961) 216–217.